The Declining Role of Deposits in Credit Creation*

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Abstract

Does deposit funding still drive credit creation? Deposit inflows affect credit through a feedback loop between lending and deposit creation. Using high-frequency identification of exogenous deposit inflows, we estimate that a \$1 deposit inflow increases cumulative deposits by \$2.05, but that this amplification declines sharply over time, from 2.6 to 1.3. We develop a structural model to recover banks' lending response to deposit inflows and the recycling of loan proceeds into stable funding. We find that banks' lending response has more than halved, and that deposit recycling has declined by 20 percent. As a result, the total effect of a \$1 deposit inflow on bank credit has declined from 1.7 to 0.4, so each dollar of deposits today creates less than one quarter of the credit it once did. Both tighter capital requirements and weaker deposit recycling drive this decline, while liquidity requirements partially offset it. The reduction in recycling is consistent with a diminished specialness of bank deposits and a greater use of non-bank alternatives. The results imply an implicit narrowing of banking that dampens credit creation and alters the transmission of monetary and fiscal policy.

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1 Introduction

Does deposit funding still drive credit creation? Stable bank deposits are widely thought to support bank lending and maturity transformation, as they relax banks' liquidity management (Diamond and Dybvig, 1983; Kashyap et al., 2002a). Moreover, the act of lending itself can generate new stable deposits, generating a feedback loop that amplifies the overall effect of deposit inflows on credit creation (Tobin, 1963; Friedman and Schwartz, 1963). Despite its potential importance, this amplification channel has received relatively little attention in the modern banking literature. We know little about the total effect of deposit inflows on bank credit provision in the modern financial system, or about the forces that determine its strength and how it evolves as the structure of the financial sector changes.

In this paper, we quantify banks' lending response to deposit inflows, the credit-deposit multiplier that captures the amplification of deposits through the feedback loop, and the resulting total effect on credit. We document a pronounced decline in all three objects over the past two decades, and use a structural model to trace these declines to shifts in primitives driven by tighter regulation and non-bank disintermediation. Our results point to an implicit narrowing of banking: deposits have become substantially less effective at generating credit, even as formal deposit-taking remains integrated with lending, with implications for the cyclicality of credit, the transmission of monetary and fiscal policy, and the supply of safe assets.

The total effect of deposit inflows on credit operates through the feedback loop between lending and deposit creation. We begin by characterizing the strength of this feedback loop in terms of two key margins: (i) banks' propensity to expand credit in response to a deposit inflow, and (ii) the extent to which bank credit expansion generates additional stable funding for the banking sector. Together, these two margins govern how strongly an initial deposit inflow propagates through successive rounds of credit creation. The resulting credit-deposit multiplier, scaled by banks' lending response to deposit inflows, yields the total effect on credit. These sufficient statistics summarize a range of underlying equilibrium forces such as funding market conditions, regulatory constraints, and household portfolio choice, which we later endogenize in a structural model to decompose changes in the multiplier.

Next, we provide empirical evidence on the magnitude and evolution of banks' credit-deposit multiplier using a high-frequency identification strategy over the period 2005-2019. Exploiting plausibly exogenous innovations in the timing of U.S. Treasury cash settlements, which mechanically credit and debit private bank accounts but are orthogonal to economic fundamentals, we instrument for contemporaneous deposit inflows and trace their propagation through the banking system using local projections. This approach allows us to recover a causal estimate of how an initial deposit inflow translates into cumulative deposit growth over subsequent weeks. Our identification strategy allows us to circumvent two key endogeneity concerns related to the estimation of the credit-deposit multiplier. The first is correlated deposit flows driven by unobserved economic conditions, and the second is real-side feedback from lending to income and deposit demand. Exploiting high-frequency innovations in Treasury settlement timing provides an exogenous source of deposit inflows, and our focus on short horizons limits the scope for real-side adjustment.

We find that the credit-deposit multiplier is sizable: a $1 deposit inflow ultimately raises cumulative deposits by $2.05 through balance sheet propagation. However, the strength of this amplification has weakened markedly over time, with the multiplier declining by roughly half from 2.6 in the first half of our sample to around 1.3 in the second half. This decline indicates a weakening of one or both of the underlying margins that govern the feedback loop: either a reduced propensity of banks to expand credit in response to deposit inflows, or a lower tendency for credit creation to generate additional stable deposit funding. Such changes may be a result of post-crisis regulatory reforms or the growing role of non-bank intermediaries in credit and liquidity provision. To disentangle these mechanisms and recover the total effect on credit, we next develop a structural model that decomposes the decline in the credit-deposit multiplier into its underlying drivers.

Our structural model features depositors and borrowers who choose between banks and non-bank outside options, alongside a banking system that sets deposit and loan rates and allocates funding across loans, securities, and wholesale borrowing. Banks' balance sheet expansion is disciplined by capital and liquidity requirements, while non-bank intermediaries compete with banks in credit markets and thereby shape the elasticity of bank credit demand. Within this environment, the credit-deposit multiplier emerges endogenously: banks' lending response is determined by underlying primitives, while the recycling of loan proceeds into stable deposits governs the evolution of the deposit base.

We estimate the model by matching model-implied optimality conditions to their empirical counterparts using aggregate U.S. banking data. The banking sector's deposit and loan first-order conditions jointly identify the shadow costs of illiquidity and leverage. The non-bank first-order condition identifies the cost of expanding non-bank credit supply, which determines how strongly non-bank lending offsets changes in bank lending. Finally, we use the reduced-form estimates of the credit-deposit multiplier in the early and late periods to pin down the recycling rate of loan proceeds into stable deposit funding. The estimated model delivers the two sufficient statistics that govern the credit-deposit multiplier: banks' marginal lending response to deposit inflows, and the recycling rate of loan proceeds into stable deposits. We find that both have declined sharply, and trace these declines to shifts in underlying primitives.

We find that banks' lending response has declined from .67 to .32. In the earlier period, banks channeled roughly two-thirds of each marginal deposit dollar into new lending; in the later period, less than one-third supports credit expansion. Most deposit inflows are now absorbed by reductions in wholesale funding or by increases in liquid asset buffers. The shift is stark: deposits have shifted from being primarily a source of credit creation to primarily a tool of balance sheet management. Tracing this decline to underlying primitives, we find that tighter capital regulation in isolation would have produced an even larger fall in banks' lending response, while the effect of liquidity regulation is more nuanced. A higher required liquidity ratio increases banks' lending response to deposit inflows, since stable deposits relax the constraint and free up capacity for credit. However, an increased share of runnable deposits reduces the extent to which inflows ease liquidity constraints, dampening the response. On balance, liquidity regulation has partially offset the decline caused by tighter capital requirements.

Moreover, we find that the recycling of loan proceeds into deposit inflows has fallen from .92 to .73. In the earlier period, over 90 cents of every dollar of loan-generated payment flows ultimately settled as stable deposits within the banking system, so that nearly all of the funds created by lending returned in a form that relaxed banks' liquidity constraints and could support further credit expansion. In the later period, only about 73 cents returns as stable deposits. This is consistent with a reduced specialness of bank deposits as a savings instrument, as households and firms increasingly allocate funds toward non-bank alternatives such as money market funds and other savings vehicles, diminishing the share of payment flows that returns to the banking system as the kind of stable, low-cost funding that supports further credit expansion. Combining the two channels, we find that tighter capital regulation can account for 80% of the observed decline in the credit-deposit multiplier, diminished deposit recycling for 60%, and that liquidity regulation on balance offsets 20% of the decline.

Turning to the central question of the paper, we find that the total effect of a deposit inflow on bank credit has declined from 1.73 to 0.42: each dollar of deposits today generates less than a quarter of the credit it once did. This total effect on credit is the product of banks' lending response and the amplification of deposits through the credit-deposit multiplier, so both forces contribute substantially to the decline. The weaker lending response reduces the credit generated in each round, while diminished deposit recycling weakens the amplification from one round to the next. As a result, the financial system has lost an important amplification channel through this implicit narrowing of the banking sector. Consequently, concerns about deposits migrating from banks to non-banks such as Stablecoins may have more muted credit effects today than they would have had in earlier periods, when deposit funding translated more powerfully into credit creation.

This raises a natural question: Has the financial system developed an alternative mechanism that can offset the loss of this bank deposit amplification channel? In particular, can the rapidly growing non-bank sector compensate for the dampened credit response in banks? Indeed, we estimate that the marginal cost of non-bank credit intermediation has roughly halved between the two periods, consistent with the growth of market-based financing. To assess whether this expansion can offset the weakening of bank-based credit creation, we examine how both bank credit and total credit respond to deposit shocks in the early and late periods. We consider scenarios in which non-banks' marginal costs decline further or in which they gain a competitive edge relative to banks. We find that non-bank credit can offset much of the decline in banks' marginal lending response, but fully offsetting the decline once the credit-deposit multiplier is taken into account is substantially more difficult. This exercise highlights that assessing the effects on total credit requires accounting not only for changes in banks' marginal lending response, but also for the strength of the underlying funding multiplier that governs amplification and that non-banks cannot easily replicate.

Overall, we find that deposits injected into the banking system generate far less cumulative amplification of credit than they did in the past, and non-bank intermediaries do not fully offset this decline. As a result, both money and credit have become less responsive to deposit inflows, dampening the amplification of the credit cycle. In this sense, our findings document an implicit narrowing of banking, driven not by institutional separation, but by regulation and non-bank competition, which has weakened the traditional feedback between deposits and credit. Deposits have become less effective at supporting credit creation, even as formal deposit-taking remains integrated with lending.

Literature Contribution.

Whether deposit funding matters for bank lending is a classic question in banking. It connects to seminal theories of why banks jointly provide deposit-taking and lending services (Diamond and Dybvig, 1983; Kashyap et al., 2002a), as well as to a more recent debate about the consequences of non-bank intermediaries eroding banks' deposit base (Whited et al., 2022). Our contribution is to quantify how deposit inflows translate into bank credit creation and to link this relationship to underlying economic primitives. By doing so, we provide a framework for evaluating how shifts in the composition of money and savings—including the migration of funds toward non-bank instruments such as money market funds or stablecoins—affect the supply of credit in the modern financial system.

Moreover, the idea that deposits and loans are connected through a feedback loop back at least to Tobin (1963), yet remains underexplored. The literature has tended to emphasize two separate views: one in which deposits fund loans, and another in which loans create deposits. In the traditional "intermediary" view, banks collect deposits from savers, hold a fraction as reserves, and lend out the remainder, so deposit market size constrains lending (Kashyap et al., 2002b; Bernanke and Blinder, 1988; Xiao, 2019). In the "money creation" view, lending itself creates deposits (Tobin, 1963; Donaldson et al., 2018), and in the absence of a binding reserve requirement is shaped by regulations, loan demand, and banks' risk appetite. Empirically, micro evidence shows that banks create deposits when they lend (Werner, 2014), aggregate deposits far exceed cash deposits (Thakor and Edison, 2024), and reduced-form estimates document a positive elasticity from lending to deposit growth (Kundu et al., 2021). Our contribution is to bridge these perspectives by quantifying the strength of the endogenous credit-deposit multiplier and the amount of deposits and credit that are ultimately created from an initial deposit inflow.[1] This multiplier highlights that deposits both constrain and are created by lending: the availability and stability of deposits shape banks' willingness to expand credit, while banks' lending decisions feed back into the deposit base. By decomposing the evolution and drivers of the multiplier, we show how the balance between these forces shifts over time.

The credit–deposit multiplier relates to amplification mechanisms emphasized in the macro-finance literature. A large body of work studies how intermediary balance sheet strength shapes

[1] While we estimate a long-term liquidity multiplier that supports credit provision, Denbee et al. (2021) and Piazzesi and Schneider (2018) study a related short-term payments liquidity multiplier, showing how transactional liquidity shapes banks' reserve management and monetary transmission.

credit supply through net worth–based amplification. Seminal contributions show how collateral values and internal liquidity constrain borrowing and investment (Kiyotaki and Moore, 1997; Holmstrom and Tirole, 1997), while Bernanke et al. (1999) highlights how stronger balance sheets reduce financing frictions and expand borrowing. Building on these foundations, intermediary-based macro models emphasize how intermediary net worth governs leverage and credit creation (Gertler and Kiyotaki, 2010; Gertler and Karadi, 2011), with implications for risk premia and asset prices (Brunnermeier and Sannikov, 2014; He and Krishnamurthy, 2013). More recent heterogeneous-bank frameworks study how these elasticities vary across institutions (Corbae and D'Erasmo, 2021; Jamilov and Monacelli, 2025). Our framework studies a closely related amplification mechanism operating through funding rather than intermediary net worth. The marginal lending response captures how strongly banks expand credit in response to deposit inflows and therefore plays a role analogous to the credit supply elasticities emphasized in this literature. While we focus on short-run balance sheet propagation through funding flows, the two mechanisms would interact at longer horizons. Lending generates profits that raise depositor wealth and bank equity, which in turn strengthen the feedback loop between deposit creation and credit supply. In this sense, the credit–deposit multiplier complements the net worth–based amplification mechanisms emphasized in the macro-finance literature.

We emphasize the importance of accounting for the recycling of loan proceeds into stable deposit funding. This connects to recent work on deposit franchise value and depositor heterogeneity in both the cross-section and the time series (Drechsler et al., 2021a,b; Li et al., 2023; DeMarzo et al., 2024; Blickle et al., 2025; Egan et al., 2025; Lu et al., 2024; Koont et al., 2024). Recent work studies how central bank reserve creation expands bank balance sheets but may fail to increase usable liquidity because banks hoard reserves in anticipation of state-contingent liquidity demand (Acharya and Rajan, 2024). In particular, deposits can become a problem if the bank expect depositors redeem jointly, which shows up in our system as deposit specialness relative to wholesale funding. While these liquidity risks also influence banks' lending incentives in our framework, we focus on a distinct amplification channel: the feedback loop between lending and deposit creation. Although all payments ultimately settle through the banking system and non-bank liabilities are backed by claims on bank deposits or reserves, our framework highlights that only stable, low-margin deposits sustain the feedback loop between lending and deposit creation. The banking sector's share of deposits can therefore be interpreted as the share of stable funding in the system, relative to more institutional or flightier deposits that do not support this amplification mechanism. Our contribution is to incorporate this recycling of deposits into the measurement of the credit–deposit multiplier and to show how changes in the composition and stability of deposits affect the strength of credit creation in the banking system.

Finally, the decline we document in the role of bank deposits in credit creation relates to the growing literature on non-bank intermediaries and the implications of a shrinking traditional banking sector (Begenau and Landvoigt, 2022; Buchak et al., 2024; Schneider et al., 2025). As non-banks increasingly disintermediate banks on both sides of their balance sheets, a smaller share of funding flows through the banking system's balance sheet amplification mechanism. This raises the question of whether the expansion of non-bank intermediation can compensate for the weakening of bank-based credit creation. We show that although non-bank credit can offset part of the decline in banks' marginal lending response, fully replacing the amplification generated by bank deposits is substantially more difficult once the credit–deposit multiplier is taken into account. Our contribution is therefore to highlight that assessing the aggregate effects of financial intermediation requires accounting not only for banks' marginal lending responses, but also for the strength of the underlying funding multiplier that governs how credit expands through the banking system.

2 Defining the Total Effect of Deposit Inflows on Bank Credit

2.1 Banks' Lending Response to Deposit Inflows

The central question in this paper is how deposit inflows translate into bank credit creation. When deposits enter the banking system, banks may expand their balance sheets by increasing lending or other assets. A natural starting point for thinking about this relationship is banks' marginal lending response to deposits, which we denote by $\lambda = dL/dD$: how much additional credit banks supply when their deposit funding increases.

However, the total effect of deposit inflows on bank credit may differ from this marginal response because deposits and lending are jointly determined within the banking system. When banks extend credit, the associated payments generate deposits elsewhere in the financial system, some of which return to banks. These newly created deposits can in turn support further balance sheet expansion. As a result, the ultimate increase in credit following a deposit inflow depends both on banks' initial lending response and on how lending activity generates new deposits within the financial system.

To formalize this idea, let D_0 denote an exogenous inflow of deposits into the banking system and let L denote bank credit. The total effect of deposit inflows on credit can be summarized by the response dL/dD_0. Understanding this relationship requires examining how deposits and lending interact in the modern banking system and how balance sheet adjustments following deposit inflows can generate additional deposits. Section 2.2 discusses how deposits and lending are jointly determined in a fractional-reserve banking system. Section 2.3 illustrates the mechanism through a simple example. Finally, Section 2.4 formally defines the total credit effect by decomposing it into banks' marginal lending response and the amplification generated by deposit creation within the financial system.

2.2 The Link Between Deposits and Bank Credit

To understand how deposit inflows translate into bank credit creation, we begin by discussing how deposits and lending are jointly determined in the modern banking system, where banks operate with fractional reserves and are not constrained by binding reserve requirements. In such an environment, the effect of deposit inflows on credit depends on how bank balance sheets adjust and whether lending activity generates additional deposits within the financial system.

As a benchmark, consider a fully narrow banking system in which deposits are backed one-for-one by central bank reserves, as illustrated in Figure 1. Under narrow banking, the aggregate quantity of deposits is fixed by reserves, so that $Q^* = R$, where R denotes aggregate reserves. In this case, the aggregate supply of deposits is perfectly inelastic. Changes in the demand for deposits shift equilibrium deposit rates r^* but do not affect the quantity of deposits.

In contrast, in a fractional reserve banking system as in Figure 2, deposits are jointly determined by (i) households' willingness to hold deposits and (ii) banks' willingness to expand their balance sheets and issue deposit liabilities (e.g., to fund loans and securities). Unlike in a narrow system, banks are not required to hold reserves one-for-one against deposits. Instead, they choose balance sheet size to maximize their profits subject to liquidity and capital management or regulatory constraints that limit how much asset expansion can be supported by a given stock of liquid resources. In this environment, shifts on either side of the market affect both equilibrium rates and quantities. Bank balance sheet expansion can therefore be initiated either by an increase in deposit demand, arising from changes in household preferences or portfolio

Narrow Banking

Assets		Liabilities	
Reserves	R	Deposits	R
	R		R

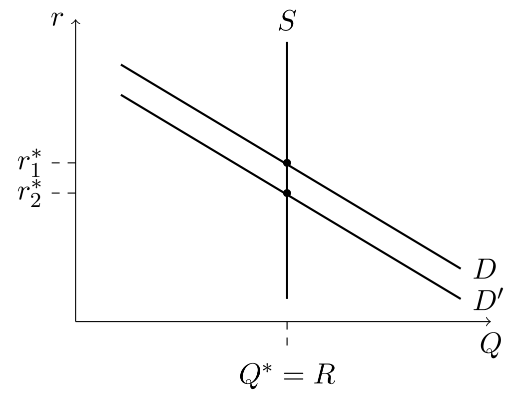


Figure 1: Narrow banking: deposits are backed one-for-one by reserves, so deposit quantity is pinned down by aggregate reserves. Demand shifts change equilibrium rates but not quantities.

Fractional Reserve Banking

Assets		Liabilities	
Reserves	R	Deposits	D
Loans / Securities	A		
	$R + A$		D

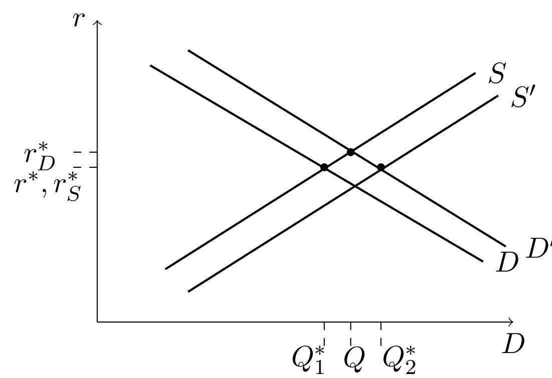


Figure 2: Non-narrow banking: deposits are jointly determined by an upward-sloping deposit supply curve (banks' willingness to expand balance sheets) and a downward-sloping deposit demand curve (households' willingness to hold deposits). Shifts in either demand or supply move both equilibrium rates and quantities.

allocations toward deposits, or by a shift in credit supply, reflecting improvements in lending opportunities or changes in banks' regulatory environment that make asset expansion more attractive.[2]

We see evidence of this deposit creation in the U.S. banking sector when we examine the evolution of key monetary aggregates over time. We focus on two standard measures of money that are most directly linked to the banking system's role in money creation. M0, or the monetary base, includes currency in circulation and reserves held by banks at the central bank and represents the supply of base money injected by the central bank. M1, or narrow

[2]This example abstracts from banks' non-deposit wholesale funding adjustment. Allowing for this margin would imply that balance sheet expansion occurs net of funding adjustments, as formalized in our model in Section 4.

money, expands on M0 by adding demand deposits and other highly liquid checkable deposits. Comparing these two aggregates illustrates how the stock of bank deposits compares to reserves. In Figure 3, we plot the evolution of M1/M0 from 1960 through 2025. The fact that the ratio fluctuates over time, and generally exceeds 1, is consistent with banks creating deposits through lending.

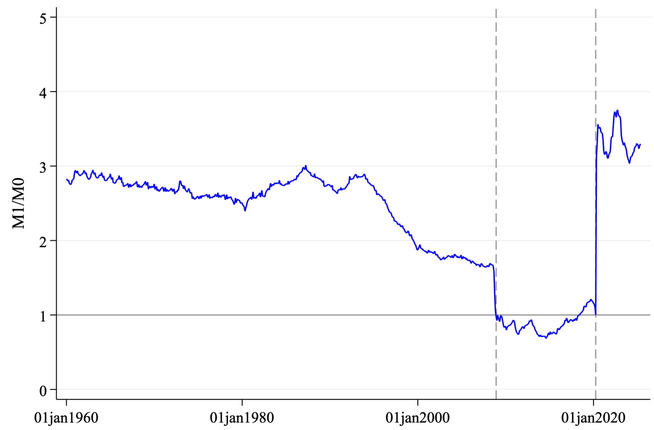


Figure 3: Evolution of M1/M0. Monthly data is from FRED (1960–2025). Vertical lines denote the onset of QE after the 2008 financial crisis and pandemic-related stimulus. In May 2020, savings deposits were reclassified as transaction accounts and added to M1.

The fact that banks create deposits to expand their balance sheets does not, by itself, imply the existence of a feedback loop between deposits and lending. Such amplification arises only if banks respond to additional deposits by expanding lending, so that the marginal lending response to deposits, dL/dD, is positive. This condition is likely to hold in practice because deposits, when they constitute stable funding, relax banks' liquidity constraints at the margin and thereby support additional balance sheet expansion. As a result, deposits created through lending can return to the banking system as funding and support further balance sheet expansion, so that an initial deposit inflow may generate successive rounds of balance sheet expansion within the banking system. The ultimate increase in credit can therefore exceed banks' initial lending response to deposits.

2.3 A Simple Example

Beginning from an equilibrium quantity of deposits, an initial change in deposits—whether originating from a shift in demand or supply—can affect banks' balance sheets through its impact

Table 1: Simple Example: Credit-Deposit Multiplier

Initial

Assets		Liabilities	
R	\$100	W	\$100
	\$100		\$100

Deposit Inflow

Assets		Liabilities	
R	\$100	D	\$100
		W	\$0
	\$100		\$100

Loan Origination

Assets		Liabilities	
R	\$100	D	\$100
L	\$70	W	\$70
	\$170		\$170

Deposit Recycling

Assets		Liabilities	
R	\$100	D	\$163
L	\$70	W	\$7
	\$170		\$170

Loan Origination

Assets		Liabilities	
R	\$100	D	\$163
L	\$114	W	\$51
	\$214		\$214

Reserves are fixed. We assume the deposit inflow replaces wholesale funding one-for-one. The banking sector then expands lending by $\lambda = 0.7$ per dollar of stable deposits, creating flighty funding (modeled as wholesale liabilities) alongside the new loans. A fraction $\theta = 0.9$ of flighty balances is recycled into stable deposits, raising deposits and initiating the next round.

on funding conditions. If the deposits created through lending remain within the banking system as stable funding, they may relax banks' liquidity constraints at the margin and enable further balance sheet expansion. In this case, an initial change in deposits can propagate through the banking system as lending activity generates additional deposits that support further lending. The following example illustrates this mechanism in a simple setting.

This example illustrates how an initial deposit inflow can propagate through the banking system via successive rounds of balance sheet expansion. Table 1 illustrates the mechanics using a consolidated balance sheet for the aggregate banking system.

Suppose there is a preference shock that leads \$100 from money market funds into bank deposits. Because deposits are superior to wholesale funding in their stability relative to bank liquidity requirements, the inflow replaces \$100 of wholesale funding with \$100 of stable deposits, leaving total assets unchanged but improving the banking sector's liability composition. The relaxation in liquidity requirements raises the banking sector's willingness to lend and expand the balance sheet. The banking sector issues a loan which simultaneously creates wholesale deposits. In this simple example, the initial inflow of stable deposits supports \$70 of new loans. In summary, after the first round, loans and assets rise by \$70.

As borrowers spend the loan proceeds, payments circulate through the economy. A frac-

Table 2: Aggregate Banking System: Incremental Expansion by Round

Round	**Deposits**	**Loans**
Initial Inflow	\$100.0	\$70.0
Round 2	\$63.0	\$44.1
Round 3	\$39.7	\$27.8
Round 4	\$25.0	\$17.5
Total (Limit)	**\$270.3**	**\$189.2**

The table reports incremental balance sheet expansion by round in the aggregate system. Each round generates new lending equal to $\lambda = 0.7$ times newly retained deposits, and newly retained deposits equal to $\theta = 0.9$ times the previous round's lending. Successive rounds shrink by the factor $\lambda\theta = 0.63$, and totals converge.

tion of these balances returns to the banking system as stable deposits. Deposits therefore rise from \$100 to \$163, while wholesale funding declines correspondingly. The improvement in funding composition again supports further lending and balance sheet expansion.

After two rounds, deposits have increased to \$163 and loans to \$114. This process continues with diminishing magnitude. We display the iterative balance sheet item effects in Table 2. Iterating forward, total deposits converge to \$270 and loans to \$189. Amplification arises because stable deposits are superior to wholesale funding: they relax regulatory and liquidity constraints, and loan-generated payment flows partially recycle into new deposits. The interaction between banks' lending response and the retention of payment flows governs the strength of the credit–deposit multiplier.

2.4 The Total Effect of Deposit Inflows on Bank Credit

The simple example above illustrates how an initial deposit inflow can propagate through the banking system via successive rounds of lending and redepositing. As discussed in Section 2.1, a natural starting point for thinking about the effect of deposit inflows on credit is banks' marginal lending response to a deposit inflow, λ. However, because a portion of loan proceeds may return to the banking system as deposits, an initial deposit inflow can generate additional rounds of balance sheet expansion. This mechanism implies that the ultimate increase in credit may exceed banks' initial lending response to deposits. We formalize this mechanism using a simple propagation framework that separates banks' lending response from the recycling of deposits within the financial system.

Formally, we define the *Credit-Deposit Multiplier* m_D as the total change in the deposit base, ΔD_{total}, generated by an initial deposit inflow ΔD_0. Two sufficient statistics govern this process. The first is λ, which corresponds to banks' marginal lending response to deposit inflows. The second is θ, which reflects the marginal propensity for credit-financed expenditures to be redeposited within the banking system as stable bank deposits. Together, these parameters determine how an initial deposit inflow propagates through the system.

Given a deposit inflow ΔD_0, banks extend new loans in the amount $\lambda \Delta D_0$, of which a fraction θ returns as deposits, raising the deposit base to $\Delta D_0 + \lambda\theta\Delta D_0$. These new deposits $\lambda\theta\Delta D_0$ then support additional lending of $\lambda^2\theta\Delta D_0$, of which a fraction θ recycles as deposits, and the process continues. Iterating forward, we can express the total deposit expansion from an initial inflow ΔD_0 as a geometric series:

$$\Delta D_{t-1,t+h} = \Delta D_0 \left(1 + \lambda\theta + (\lambda\theta)^2 + \cdots + (\lambda\theta)^h\right). \tag{1}$$

The corresponding credit-deposit multiplier at horizon h is:

$$m_D^h = 1 + \lambda\theta + (\lambda\theta)^2 + \cdots + (\lambda\theta)^h. \tag{2}$$

As $h \to \infty$, the process converges (provided $|\lambda\theta| < 1$), yielding the long-run credit-deposit multiplier:

$$m_D = \frac{1}{1 - \lambda\theta}. \tag{3}$$

The credit-deposit multiplier m_D describes how an initial deposit inflow expands the deposit base through successive rounds of lending and redepositing. To recover the total effect of deposit inflows on bank credit, we combine this amplification mechanism with banks' marginal lending response to deposits. Specifically, if banks expand lending by λ for each additional dollar of deposits, then the total increase in credit generated by an initial deposit inflow ΔD_0 is given by

$$\Delta L_{total} = \lambda m_D \Delta D_0. \tag{4}$$

This expression highlights that the total credit effect of deposit inflows depends both on banks' initial lending response to deposits and on the amplification generated by the recycling of deposits within the banking system.

In the Appendix we consider whether non-bank institutions can generate a similar funding multiplier by issuing money-like liabilities such as commercial paper or repo. Although balance sheet amplification can arise through collateral reuse, these mechanisms are generally weaker than the credit-deposit multiplier because non-bank liabilities do not function as the primary settlement asset. We therefore focus on banks in the main text and abstract from non-bank multipliers.

3 Empirical Analysis

3.1 Deposits and Bank Credit

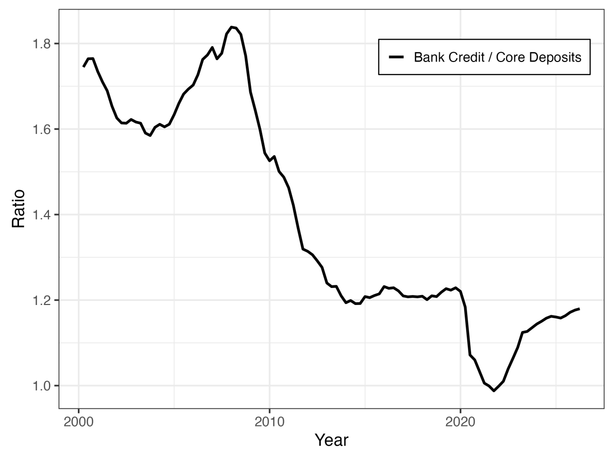
Before turning to our causal estimates, we begin with a descriptive fact about the relationship between deposits and bank credit. Figure 4 plots the ratio of bank credit to core deposits for U.S. commercial banks.

The figure shows a marked decline in this ratio over the past two decades. In the early 2000s, bank credit was roughly comparable in size to the stock of core deposits. Since the Global Financial Crisis, however, bank credit has grown substantially more slowly than deposits, leading to a persistent decline in the credit-to-deposit ratio.

The decline in the credit-to-deposit ratio in Figure 4 is consistent with the broader shift away from traditional bank balance sheet lending documented by Buchak et al. (2024). Our focus, however, is different. Rather than studying the rise of non-bank lenders directly, we examine the changing role of deposits in generating bank credit. In particular, we study whether deposit inflows continue to translate into credit creation through the deposit multiplier. A decline in the effectiveness of deposits in generating new lending would imply a weakening of the traditional money creation mechanism through which banks expand credit. Estimating this relationship empirically requires isolating variation in deposits that is not driven by underlying economic conditions or credit demand.

Figure 4: Bank Credit Relative to Core Deposits

This figure plots the ratio of bank credit to core deposits for U.S. commercial banks. Bank credit is measured as total loans, leases, and securities held by U.S. commercial banks (FRED series TOTBKCR). Core deposits are defined as total deposits excluding large time deposits (DPSACBW027SBOG minus LTDACBW027SBOG). The weekly banking series are converted to quarterly frequency using the final observation within each quarter. The sample begins in 2000.



3.2 Empirical Strategy and Data

To estimate banks' credit-deposit multiplier, we measure how an initial deposit inflow translates into a total change in deposits. A natural way to implement this is to estimate local projections of deposits at horizon h on a shock to deposits at time t:

$$\Delta D_{t+h} = \alpha_h + m_D^h \cdot \Delta D_t + \Gamma_h X_t + \varepsilon_{t+h}. \tag{5}$$

In Equation (5), $\Delta D_t \equiv \log D_t - \log D_{t-1}$ captures deposit growth from period $t-1$ to t, $\Delta D_{t+h} \equiv \log D_{t+h} - \log D_{t-1}$ captures cumulative deposit growth from $t-1$ to $t+h$, X_t denotes a vector of controls dated at time t, and ε_{t+h} is the error term. In this setting, the coefficient m_D^h represents the credit-deposit multiplier at horizon h. As h grows large, m_D^h converges to the long-run credit-deposit multiplier m_D.

If all other determinants of deposit growth were fully accounted for in X_t, then local projections would deliver unbiased estimates of m_D^h at each horizon, converging to the true credit-deposit multiplier m_D for large h. However, in practice, many relevant factors that influence deposit dynamics, such as local demand conditions, interest rate expectations, or shifts in portfolio preferences, are difficult or impossible to observe. As a result, ΔD_t may be correlated with the error term ε_{t+h}, giving rise to endogeneity and biasing our estimate of m_D. For instance, we may overestimate m_D if ΔD_t and ΔD_{t+h} co-move positively because of an unobservable factor that drives deposit flows at both horizons, such as a surge in aggregate risk appetite or liquidity demand.

To address this endogeneity concern, we seek a shifter of contemporaneous deposit growth, ΔD_t, that is uncorrelated with the unobservable factors that jointly drive both current and future deposit growth. We instrument ΔD_t using a Treasury cash-flow timing innovation constructed from the Daily Treasury Statement (DTS). At weekly horizons, Treasury payments and receipts credit and debit private bank accounts, and unexpected variation in the timing of these cash settlements reflects administrative processing rather than changes in economic fundamentals, making it a plausibly exogenous shifter of core deposits. Concretely, when the Treasury makes net payments to the private sector—for instance, paying contractors in one week versus the next—the TGA balance at the Fed declines, commercial bank reserves increase, and recipients' deposit accounts are credited in that week. Administrative processing factors can shift these settlements across weekly reporting periods, creating exogenous variation in weekly deposit growth across banks based on their depositor composition. This identification strategy generalizes the Treasury General Account (TGA) shocks used in prior work to a longer time period, while preserving the same high-frequency, plumbing-based source of exogenous variation in deposits (Correa et al., 2020).

Specifically, we aggregate daily Treasury withdrawals and deposits of operating cash reported in the Daily Treasury Statement into weekly net cash flows CF_t, treating deposits of operating cash as negative values so that positive realizations correspond to net Treasury payments to the private sector. We then purge this weekly series of predictable variation by residualizing on quarter-year fixed effects α_q, calendar week-of-year fixed effects α_w, and six lags of the weekly cash-flow series as in Equation (6), and use the resulting innovation, Z_t, as our instrument.[3]

$$CF_t = \alpha_q + \alpha_w + \sum_{k=1}^{6} \rho_k \, CF_{t-k} + Z_t. \tag{6}$$

[3]We include all operating cash categories except for internal transfers to and from the Federal Reserve, the TGA, and depository institutions, and counter-cyclical means-based transfers including unemployment insurance, food assistance, and TANF, which may correlate with broader economic conditions. We exclude October 2008, which coincides with extraordinary fiscal and financial interventions during the Great Financial Crisis.

By construction, this innovation captures unexpected timing variation in Treasury settlement flows, rather than changes in fiscal policy, aggregate income, or credit conditions. Indeed, the Ljung-Box portmanteau test fails to reject the null of no serial correlation in the innovation up to six weekly lags, consistent with the interpretation of the shock as high-frequency timing noise at the horizons that we use to estimate the deposit multiplier.

We implement this strategy in a 2SLS framework. To accommodate potential short-run timing dispersion between Treasury settlement and the recording of deposit balances, we instrument contemporaneous deposit growth $\Delta D_t \equiv \log(\text{Deposits})_t - \log(\text{Deposits})_{t-1}$ using both the contemporaneous and one-period lag of the Treasury cash-flow timing innovation, allowing the first stage to load on delayed effects without imposing serial correlation on the shock itself. We measure deposits using aggregate core deposits from FRED, defined as total deposits held by all U.S. commercial banks excluding large time deposits. Our first stage specification is as follows,

$$\Delta D_t = \alpha + \beta_1 Z_t + \beta_2 Z_{t-1} + \Gamma_h X_t + \mu_t. \tag{7}$$

In the second stage, we regress cumulative deposit growth at horizon h, $\Delta D_{t-1,t+h} \equiv \log(\text{Deposits})_{t+h} - \log(\text{Deposits})_{t-1}$ on instrumented deposit growth at time t within the local projection framework. In the vector of controls X_t we include the lag of deposit growth ΔD_{t-1}. For horizon h, the second stage regression equation is,

$$\Delta D_{t-1,t+h} = m_D^h \widehat{\Delta D}_t + \Gamma_h X_t + \varepsilon_{t+h}. \tag{8}$$

Instrument validity requires that the relevance and exclusion assumptions be satisfied. The relevance condition is supported by our first-stage F-statistics in Table 3. Intuitively, Treasury payments and receipts credit and debit private bank accounts, generating changes in aggregate core deposits at weekly horizons. The exclusion restriction requires that innovations in Treasury cash-flow timing affect future deposit growth only through its impact on contemporaneous deposit growth ΔD_t, and not through any other channel. This is plausible because, after removing predictable seasonality and persistence, the remaining high-frequency variation in Treasury cash-flows largely reflects administrative settlement timing across a large number of payment streams. A related concern is that our empirical specification may capture real-side economic responses rather than balance sheet propagation. In principle, deposit inflows could support new lending that stimulates economic activity, raising incomes and wealth and thereby shifting out

Table 3: First Stage Estimates

The table reports first-stage estimates from the instrumental variables specification linking national core deposit growth to Treasury cash-flow timing innovations. The sample covers 2005–2019. Standard errors are reported in parentheses. Coefficients on the instrument and its lag are scaled by 10,000. One, two, and three stars indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1) 2005-2019	(2) 2005-2011	(3) 2012-2019
L.Instrument	0.17***	0.27***	0.09
	(0.05)	(0.09)	(0.06)
Instrument	0.18***	0.20**	0.15**
	(0.05)	(0.09)	(0.06)
L.Deposit Growth	-0.28***	-0.25***	-0.31***
	(0.04)	(0.05)	(0.05)
Observations	731	314	417
Adjusted R^2	0.094	0.089	0.106
F	26.36	11.20	17.36

the demand for deposits. However, such real-side adjustments typically unfold over longer horizons, and the six-week window we study is likely too short for these mechanisms to operate meaningfully. As a result, real-side feedback effects are unlikely to play a first-order role in driving the magnitude of our estimated deposit multiplier.

Thus, our empirical strategy allows us to estimate how cumulative deposit growth responds to an initial exogenous inflow through balance sheet propagation, thereby recovering a causal estimate of the deposit multiplier.

3.3 Estimates of the Deposit Multiplier

Figure 5 visualizes the coefficient estimates for our IV specification in Equation (8) at horizons h from 0 to 6, with shaded bands indicating 95% confidence intervals. This specification captures how an initial funding inflow propagates through the banking system over time, including through flows of funds between banks and across institutions. We define the long-run multiplier m_D^h as the peak cumulative response, resulting in a value of 2.05. This implies that a 1 percent deposit inflow ultimately leads to a 2.05 percent increase in total deposits in the banking system.

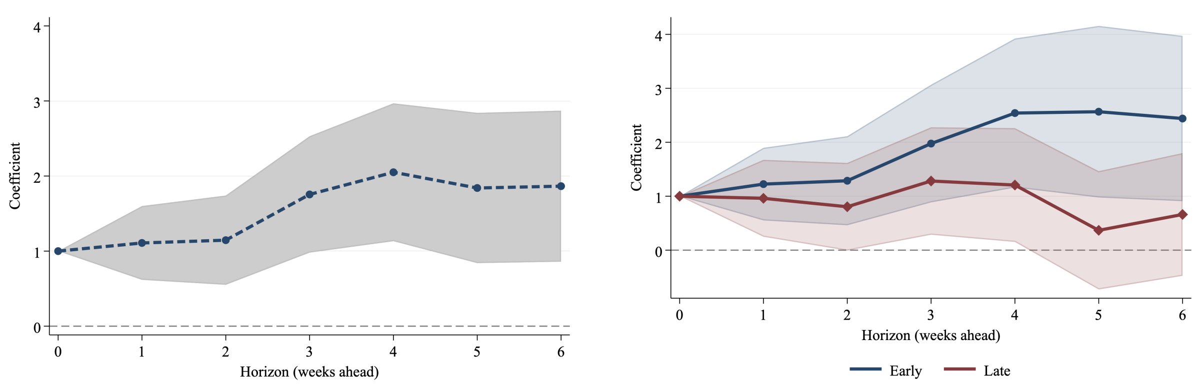
The impulse response indicates that initial deposit inflows are gradually re-deposited within the banking system, leading to additional rounds of deposit growth across local institutions. These effects level off after several weeks, suggesting that the cumulative response has converged to the overall deposit multiplier.

We next examine its time variation. We split our time sample into an early and late period, estimating the credit-deposit multiplier over the years 2005-2011 and 2012-2019. Figure 5 Panel B compares the dynamics of the deposit multiplier across two sample periods. We estimate, for each period, our IV specification in Equation (8) at horizons $h = 0$ to 6. Comparing the magnitudes shows a marked decrease in the latter sample, falling from 2.57 in the earlier period to only 1.28.

The decline in banks' credit-deposit multiplier implies a reduced propensity of banks to expand credit in response to deposit inflows (λ), a lower tendency for credit proceeds to be retained within the banking system as stable deposits (θ), or both. Such changes may reflect post-crisis regulatory reforms as well as the expanding role of non-bank intermediaries in funding and credit provision. To disentangle these channels, we next develop a structural model that quantitatively decomposes the decline in the multiplier and assesses the relative contribution of each of these forces.

Figure 5: Deposit Multiplier Estimates

This figure reports local projection estimates of the dynamic response of deposits to a deposit shock at time t, estimated using an instrumental variables approach. Panel (a) shows the full-sample estimate from 2005 to 2019. Panel (b) compares estimates for the early (2005-2011) versus late (2012-2019) samples. Shaded bands denote 95% confidence intervals.



(a) Full Sample

(b) Early vs. Late

4 Model

In this section, we develop a structural model of the U.S. banking sector that endogenizes the credit–deposit multiplier and links its magnitude to underlying structural primitives, allowing us to quantitatively decompose the forces driving its evolution. Within this environment, the sufficient statistics that govern the multiplier, namely banks' lending response λ and the retention rate of stable deposits θ, are endogenously determined in equilibrium.

4.1 Overview

The model features three types of agents. There are depositors, borrowers, and a representative banking system. The key exogenous variables in the model are the current policy rate r^S and the equity capital of the banking sector E, which characterize the state of the world. Given these variables, banks maximize profits by competing for depositors and allocating funds across securities and loans, subject to capital and liquidity constraints. Depositors and borrowers maximize their utility by choosing whether to bank with the banking sector or a non-bank outside option.

4.2 Depositors

Depositor behavior plays a central role in shaping the deposit multiplier through banks' funding conditions. The level and elasticity of deposit demand determine the size and composition of banks' funding base, which in turn affects the tightness of capital and liquidity constraints governing balance sheet expansion. In addition, because deposits provide valuable liquidity and safety services, banks can attract funding while paying deposit rates below the policy rate r^S. Through these channels, deposit market conditions influence banks' equilibrium pricing and balance sheet capacity, and therefore shape how deposit inflows are transformed into lending. We model deposit markets through a simple portfolio choice framework that captures these features.

There is a mass W^d of depositors. While taken as fixed by the banking sector, we show the stock of money evolves endogenously over time with the deposit multiplier. Each depositor i makes a discrete choice over a menu that includes a bank deposit, a non-bank savings vehicle, and cash, which differ in the yields they offer and the liquidity services they provide. Funding that flows to non-bank vehicles sits outside the banking system.[4]

Household i's utility from a bank deposit is

$$u_i^d \;=\; \alpha_d r^d + \xi_d + \varepsilon_i, \tag{9}$$

while for a money market fund (MMF) it is

$$u_i^M \;=\; \alpha_d r^S + \varepsilon_i^M, \tag{10}$$

and for cash it is

$$u_i^C \;=\; \xi_C + \varepsilon_i^C. \tag{11}$$

Here r^d is the bank deposit rate, α_d is the deposit rate sensitivity of depositors, ξ_d captures the relative liquidity and safety value of bank deposits, and ε_i is the idiosyncratic taste shock for depositor i. Shocks to ξ_d can generate deposit flows within the system rather than exogenous flows from outside the system. The non-bank savings vehicle, such as a money market fund or stablecoin, pays the policy rate r^S but provides no liquidity services. In contrast, cash offers liquidity services ξ_C but pays no interest.

We assume that the error term ε_i is distributed according to a Type-1 extreme value distribution, allowing for a closed form solution of the choice probabilities. This leads to the market share of deposits $s_d(r^d|r^S)$,

$$s_d(r^d|r^S) \;=\; \frac{e^{\xi_d+\alpha_d r^d}}{e^{\xi_d+\alpha_d r^d} \;+\; e^{\alpha_d r^S} \;+\; e^{\xi_C}}. \tag{12}$$

Given this, the demand for deposits can be written as,

$$D(r^d|r^S) \;=\; s_d(r^d|r^S) \cdot W^d. \tag{13}$$

[4]In practice, such funds may re-enter, but typically as less stable, higher-yield institutional deposits rather than core deposits.

4.3 Borrowers

The strength of the credit–deposit multiplier influences banks' lending behavior through funding frictions that determine the loan rates offered to borrowers. To analyze these credit-side implications, we model loan markets in parallel with deposit markets.

There is a mass of borrowers with wealth W^b. Each borrower j makes a discrete choice over a menu that includes borrowing from the bank, borrowing from non-bank lenders, and not borrowing. Borrower j's utility for a bank loan is

$$u_j^\ell \;=\; -\alpha_\ell r^\ell + \xi_\ell + \eta_j, \tag{14}$$

where r^ℓ is the bank loan rate, α_ℓ is the rate sensitivity of borrowers, ξ_ℓ captures the relative desirability of bank services, and η_j is the idiosyncratic taste shock for borrower j.

Similarly, borrower j's utility for a non-bank loan is

$$u_j^{nb} \;=\; -\alpha_\ell r^{nb} + \xi_{nb} + \eta_j, \tag{15}$$

where r^{nb} is the non-bank loan rate and ξ_{nb} captures the relative desirability of non-bank services. We normalize the utility of not borrowing to zero. We assume that η_j follows a Type-1 extreme value distribution. This leads to the market share of bank loans,

$$s_\ell(r^\ell, r^{nb}) \;=\; \frac{e^{\xi_\ell - \alpha_\ell r^\ell}}{1 + e^{\xi_\ell - \alpha_\ell r^\ell} + e^{\xi_{nb} - \alpha_\ell r^{nb}}}, \tag{16}$$

and the corresponding market share of non-bank loans,

$$s_{nb}(r^\ell, r^{nb}) \;=\; \frac{e^{\xi_{nb} - \alpha_\ell r^{nb}}}{1 + e^{\xi_\ell - \alpha_\ell r^\ell} + e^{\xi_{nb} - \alpha_\ell r^{nb}}}. \tag{17}$$

Loan quantities are given by

$$L \;=\; W^b s_\ell(r^\ell, r^{nb}), \qquad L_{nb} \;=\; W^b s_{nb}(r^\ell, r^{nb}). \tag{18}$$

4.4 Banking System

4.4.1 Profit Maximization

We model a representative banking sector that chooses the deposit rate r^d, loan rates r^ℓ, and wholesale borrowing W to maximize profits. It takes as given the policy rate r^S, equity capital E, and the demand functions of depositors $D(r^d)$ and borrowers $L(r^\ell)$. Non-negative cash reserves R are then determined residually by the balance sheet constraint,[5]

$$L(r^\ell) + R = E + D(r^d) + W. \tag{19}$$

The banking sector's profit maximization problem is given by,

$$\max_{r^d, r^\ell, W} (r^\ell - r^S)L \; + \; (r^S - r^d)D \; - \; \frac{\kappa_W}{2}W^2 \; + \; \xi \ln\big(K\big) \; + \; \tau \ln\big(\Lambda\big). \tag{20}$$

In (20), the first two terms capture profits from loan and deposit markets respectively.[6] The remaining terms represent costs: a quadratic wholesale funding cost κ_W, reflecting the expense of external financing outside the bank's deposit base (Kashyap and Stein, 1995), and penalties from capital and liquidity requirements, which we describe in detail below. These frictions link deposit-taking to loan supply: without them, deposit inflows would have no effect on lending, and the credit-deposit multiplier would reduce to one.

We model banks' regulatory capital and liquidity constraints with log penalties, which reduce profits by raising marginal costs as the capital or liquidity slack approaches zero. First, the bank faces a risk-invariant capital constraint captured by $\xi \ln\big(K\big)$. Letting $\kappa > 0$ denote the level of the capital requirement, let the capital slack K be defined as

$$K \; = \; E - \kappa\,(L + R) \; = \; (1 - \kappa)E \; - \; \kappa(D + W) \geq 0. \tag{21}$$

Thus, the capital slack K is the excess of equity capital E over a fixed fraction κ of total assets, with loans and reserves weighted uniformly. This risk-invariant leverage ratio is similar to the

[5]For expositional clarity, we treat reserves R as fixed in this section. In the Appendix and in the quantitative calibration, we allow banks to manage cash reserves endogenously.

[6]Reserves and wholesale funds both earn the policy rate r^S. With equity E fixed, their returns affect the level of profits but not the bank's profit maximization.

Supplementary Leverage Ratio (SLR) implemented in the Basel III regulatory framework. By rearranging with the balance sheet identity, we see that higher deposits D and wholesale funding W tighten the constraint, while greater equity E relaxes it. As the balance sheet grows relative to equity, the capital slack K shrinks, and the penalty $\xi \ln(K)$ reduces profits, making additional asset expansion increasingly costly.

Second, the bank faces a liquidity requirement captured by $\tau \ln\big(\Lambda\big)$. Let $\chi \in [0,1]$ be the required ratio of liquid asset holdings relative to runnable liabilities, and $\psi \in [0,1]$ governs the runnable fraction of deposits in the liquidity rule. Define the liquidity slack Λ as,

$$\Lambda = R - \chi(\psi D + W) \geq 0 \tag{22}$$

Here, the liquidity slack Λ is the excess of liquid reserves R over a required fraction χ of runnable liabilities, given by the runnable share ψ of deposits D and all wholesale funding W. This formulation is in the spirit of the Liquidity Coverage Ratio (LCR) in Basel III, which requires banks to hold sufficient high-quality liquid assets to cover a fraction of their runnable short-term liabilities. From (22), higher runnable liabilities such as wholesale funding W or runnable deposits ψD tighten the constraint, while greater reserves R relax it. As runnable funding rises without a matching increase in liquid assets, the liquidity slack Λ shrinks, and the penalty $\tau \ln(\Lambda)$ reduces profits, making reliance on unstable funding increasingly costly.

The parameters $\xi, \tau > 0$ govern the severity of the capital and liquidity constraints. They determine how sharply profits decline as the corresponding slacks K and Λ shrink, with larger values implying that the constraints impose higher marginal costs when balance sheet capacity becomes scarce. Intuitively, higher ξ or τ capture a more stringent regulatory environment or a greater sensitivity of bank funding costs to tight capital or liquidity positions.[7]

[7] Notice that both the capital and liquidity constraints tighten mechanically with the quantity of deposits, as higher deposits increase total liabilities and runnable funding. However, a deposit inflow can relax these constraints in equilibrium as banks optimally reallocate their balance sheets, to the extent that it lowers the shadow cost of liquidity and does not substantially raise the shadow cost of capital. The effective tightness of funding constraints depends on how deposit inflows are absorbed and distributed across assets and liabilities.

4.4.2 First Order Conditions

Given the profit maximization problem above, we next derive the corresponding first order conditions. We begin with the condition for the loan rate $r^{\ell *}$,

$$r^{\ell\star} = r^S + \frac{1}{\alpha_\ell(1 - s_\ell(r^{\ell\star}))} + \frac{\tau}{\Lambda^*} \tag{23}$$

This expression shows that the banking sector's optimal loan rate $r^{\ell\star}$ can be written as the sum of three terms. The first is the policy rate, which provides the baseline cost of funds in the economy. The second is a demand markup, reflecting the bank's market power arising from borrowers' preference for bank loans: when loan demand is less elastic, the bank sets a higher rate above the policy rate. The third is a liquidity wedge, which arises when the bank must hold liquid assets against runnable liabilities, increasing the effective marginal cost of extending loans.[8] This term, τ/Λ, can be interpreted as the shadow cost of liquidity: the marginal value of relaxing the liquidity constraint by one unit. When liquidity is scarce and Λ is small, this shadow cost is high, raising lending rates; when liquidity is ample, the shadow cost approaches zero, and the loan rate converges toward the policy rate plus the demand markup.

Next, we solve for the optimal deposit rate $r^{d\star}$,

$$r^{d\star} \;=\; r^S \;-\; \frac{1}{\alpha_d \left(1 - s_d(r^{d\star} \mid r^S)\right)} \;+\; (1 - \chi\psi)\frac{\tau}{\Lambda^\star} \;-\; \kappa\,\frac{\xi}{K^\star} \tag{24}$$

The deposit first order condition implies that the optimal deposit rate reflects three forces beyond the policy rate. First, a deposit markdown arises from market power: when deposit demand is less elastic, the bank can offer a rate below r^S. Second, deposits affect the liquidity constraint by altering runnable liabilities and reserves. When deposits are less runnable ($\psi < 1$), they relax the liquidity requirement, increasing the marginal value of funding. The term $(1 - \chi\psi)\frac{\tau}{\Lambda^\star}$ captures this liquidity effect, which is stronger when liquidity slack $\Lambda^\star$ is small. Third, deposits tighten the capital constraint by expanding total assets through the balance sheet identity. The term $\kappa\frac{\xi}{K^\star}$ captures this marginal capital cost, which is larger when capital slack $K^\star$ is small.

[8] Notice that the capital requirement does not enter the optimal loan rate because, in the first order condition, loans increase holding deposits and wholesale funding fixed, so reserves adjust one-for-one and total assets remain unchanged.

Overall, liquidity considerations raise deposit rates when funding is stable, while capital constraints lower them when balance sheet expansion becomes costly. The equilibrium deposit rate reflects the net effect of these two regulatory forces. Lastly, the first order condition for wholesale funding is

$$W^* = \frac{\tau}{\Lambda^*}\frac{(1-\chi)}{\kappa_W} - \frac{\xi}{K^*}\frac{\kappa}{\kappa_W}. \tag{25}$$

This expression reflects the tradeoff between liquidity and capital costs in the use of wholesale funding. The first term captures the liquidity effect: when liquidity slack Λ^* is small, the shadow value of liquidity τ/Λ^* is high, and wholesale funding increases to adjust the balance sheet. Because an increase in W raises reserves one-for-one through the balance sheet identity, the net liquidity effect depends on $(1-\chi)$. The second term captures the capital effect: wholesale funding expands total assets and tightens the leverage constraint, raising the shadow cost of capital ξ/K^*. This reduces optimal wholesale borrowing. Both forces are scaled by the quadratic funding cost κ_W, which governs how sensitively wholesale borrowing responds to regulatory wedges.

4.5 Nonbanks

We now endogenize the non-bank credit rate by introducing a representative non-bank credit intermediary. This extension affects only the asset side of credit provision. The non-bank credit intermediary supplies loans L_{nb} to firms and funds itself elastically at the short rate r_S. It takes the bank loan rate r_ℓ and the policy rate r_S as given. Scaling non-bank credit involves convex intermediation costs that capture monitoring, liquidity, and regulatory frictions outside the banking sector. Formally, the non-bank intermediary chooses the loan rate r_{nb} to solve

$$\max_{r_{nb}} \quad \Pi_{nb} = (r_{nb} - r_S)\, L_{nb}(r_{nb}, r_\ell) - C_{nb}\big(L_{nb}(r_{nb}, r_\ell)\big). \tag{26}$$

Borrower demand for non-bank credit $L_{nb}(r_{nb}, r_\ell)$ is determined by the borrower choice problem in Section 4.3. Intermediation costs take the form

$$C_{nb}(L_{nb}) = \frac{\kappa_{nb}}{2} L_{nb}^2, \qquad \kappa_{nb} > 0. \tag{27}$$

The first-order condition for r_{nb} is

$$0 = L_{nb} + (r_{nb} - r_S)\frac{dL_{nb}}{dr_{nb}} - C'_{nb}(L_{nb})\frac{dL_{nb}}{dr_{nb}}. \tag{28}$$

The optimal non-bank loan rate satisfies

$$r_{nb} = r_S + \kappa_{nb} L_{nb} + \frac{1}{\alpha_\ell(1 - s_{nb})}. \tag{29}$$

This pricing condition is analogous to the bank loan pricing equation derived above. While banks face a wedge arising from regulatory constraints, non-bank credit instead becomes increasingly costly to supply as its scale expands.

4.6 Equilibrium

An equilibrium consists of deposit and loan rates $\{r^{d\star}, r^{\ell\star}, r^\star_{nb}\}$, wholesale borrowing $W^\star$, and resulting allocations of deposits $D(r^{d\star})$, bank loans $L(r^{\ell\star})$, non-bank loans $L_{nb}(r^\star_{nb})$, and reserves $R^\star$ such that:

1. Depositors maximize utility over bank deposits, cash, and the non-bank savings vehicle, yielding deposit demand $D(r^{d\star})$.
2. Borrowers maximize utility over bank loans, non-bank loans, and not borrowing, yielding bank and non-bank loan demands $L(r^{\ell\star})$ and $L_{nb}(r^\star_{nb})$.
3. The representative banking system maximizes profits given in (20), subject to its balance sheet identity and the definitions of capital slack K in (21) and liquidity slack Λ in (22).
4. The first order conditions (23)–(25) are satisfied.
5. The non-bank loan rate $r^\star_{nb}$ satisfies the non-bank first-order condition (29).

4.7 Recovering the Credit-Deposit Multiplier

With the equilibrium in hand, we can now return to the central object of interest: the credit-deposit multiplier m_D implied by the equilibrium.[9] Recall that for a given deposit inflow dD_0, the multiplier is defined as,

$$m_D \;=\; \frac{1}{1-\lambda\theta}. \tag{30}$$

The multiplier is governed by two sufficient statistics. The first is banks' lending response λ, defined as the equilibrium derivative

$$\lambda \;=\; \frac{dL}{dD},$$

which we recover as an endogenous object from the bank's first order conditions. Intuitively, λ captures how strongly banks expand lending when deposits increase, taking into account the induced effects on wholesale funding and the capital and liquidity slacks.

The second is the recycling parameter θ, which captures the fraction of payment flows generated by lending that are retained within the banking system as stable deposits. While λ emerges from the bank's joint optimization over lending and deposit pricing, θ summarizes forces outside the bank's decision problem, such as household portfolio choice, the structure of the payment system, and the extent of non-bank intermediation. These forces determine what fraction of lending proceeds settle as stable deposits, thereby governing the equilibrium evolution of deposits.

4.7.1 Equilibrium Lending Response λ

The parameter λ summarizes how bank lending responds to changes in stable deposit funding. Intuitively, it measures how much loans expand when deposits increase in equilibrium. The analytical derivation is provided in Appendix A.2. There, we study how shocks to bank deposits work through the bank's balance sheet and regulatory constraints. Solving the system locally

[9] We adopt a static framework to keep the model tractable while capturing the key economics of the feedback loop, much like other sufficient-statistic methods used in macro-finance to study pass-throughs, wedges, or fiscal multipliers (Farhi and Werning, 2016; Gabaix, 2020; Nakamura and Steinsson, 2014). The propagation across "periods" should be interpreted as an iterative recycling of deposits rather than an intertemporal decision problem faced by forward-looking banks.

around the equilibrium yields the lending response

$$\lambda = \frac{dL}{dD} = \frac{\kappa_W + \frac{\tau\chi^2}{\Lambda^2}(1-\psi)}{\frac{1}{\tilde{\kappa}_\ell^{nb}} + \kappa_W + \frac{\tau\chi^2}{\Lambda^2} + \frac{\xi\kappa^2}{K^2}}. \tag{31}$$

Several economic forces shape this response. First, λ is larger when wholesale funding is expensive (high κ_W). In that case, deposits represent a relatively attractive source of funding, so an inflow translates more strongly into additional lending. Second, liquidity regulation plays a dual role. When deposits are more stable (low ψ), they provide greater liquidity relief compared to wholesale funding, which increases the lending response. At the same time, when liquidity is tight (low Λ or high τ), expanding loans raises the shadow cost of liquidity, dampening the response. The overall liquidity effect therefore depends on both deposit stability and how binding the liquidity constraint is.

Third, competition from nonbanks affects λ through $\tilde{\kappa}_\ell^{nb}$, which captures how responsive bank lending is to the bank loan rate once the nonbank sector adjusts endogenously.[10] When substitution between banks and nonbanks is strong and nonbank supply is relatively elastic, a given expansion in bank lending requires larger equilibrium movements in loan rates and induces greater crowding out of nonbank credit. In this case, the residual demand curve facing banks is flatter, $\tilde{\kappa}_\ell^{nb}$ is smaller, and the deposit–lending multiplier λ is lower. By contrast, when nonbank competition is weaker, banks can expand lending with smaller rate adjustments and less cross-sector reallocation, leading to a larger λ.

Finally, capital constraints discipline balance sheet expansion. When capital slack is limited (low K or high ξ and κ), additional lending tightens the leverage constraint and raises the marginal cost of credit supply, reducing λ. Overall, λ reflects the interaction of funding costs, regulatory constraints, and credit-market competition in determining how strongly deposit growth translates into bank lending.

4.7.2 Equilibrium Deposit Recycling θ

The parameter θ governs the fraction of payment flows generated by lending that is retained in the banking system as stable deposits. When the bank extends ΔL in new loans, borrowers

[10] This term is derived later and captures how the bank considers their own price and cross price elasticity.

spend the proceeds, creating new payment balances that circulate through the payment system.[11] A fraction θ of these circulating balances is retained as stable deposits, so that the recycling condition satisfies

$$dD = dD_0 + \theta\, dL.$$

Importantly, θ need not equal banks' deposit market share s_d. Balances created by lending circulate through the payment system for as long as the underlying loan remains outstanding, and can flow between accounts without permanently settling. The parameter θ captures the fraction that, at any given point in time, resides as stable deposits from the bank's perspective. This can fall below s_d for two reasons.

First, lending-driven payment flows enter the economy as compensation for goods and services rather than as a portfolio allocation. Recipients may spend these balances on their own obligations before any residual enters a savings decision, so that newly created balances circulate at a higher velocity than the existing deposit stock and a smaller fraction is resting as stable funding at any given moment. Second, marginal recipients of lending-driven payment flows—such as firms, institutional investors, or non-bank intermediaries—may have systematically different propensities to hold core deposits than the average wealth holder, paralleling the distinction between marginal and average propensities to consume in fiscal policy. Crucially, θ is not chosen by the bank and does not enter its optimization problem. Instead, it represents the payment system that determines what fraction of loan-generated balances ultimately remain as stable deposits.

4.7.3 Balance Sheet Mechanics of the Multiplier

To build intuition for how the multiplier operates, consider an exogenous stable deposit inflow dD_0.[12] In equilibrium, total deposits dD and total loans dL are jointly determined by two con-

[11] Loans are long-maturity claims. Principal is not repaid within the period in which production and payments occur, so repayment and refinancing decisions are abstracted from in the cash-flow accounting. Non-bank lending ΔL_{nb} also finances payments in gross terms, but represents a reallocation of existing cash rather than a source of net new funding.

[12] Such an inflow arises naturally from a shift in depositor preferences ξ_d that reallocates household savings from non-bank vehicles into bank deposits, or from a shift in borrower demand ξ_ℓ that stimulates lending and generates payment flows that settle as stable deposits. In either case, the inflow represents a change in the composition of bank liabilities rather than an injection of outside reserves.

ditions,

$$dL = \lambda dD \tag{32}$$

$$dD = dD_0 + \theta dL. \tag{33}$$

The first, Equation (32), is the bank's optimal lending response which states that the bank extends λ dollars of new loans for each dollar of deposits. The second, Equation (33), is the deposit recycling condition which states that total deposits equal the exogenous inflow plus the endogenous deposits created by lending: when the bank extends dL in loans, borrowers spend those funds, generating payment flows of which a fraction θ is retained within the banking system as stable deposits. Solving this system yields directly the deposit multiplier and the corresponding increase in bank loans,

$$dD = \frac{dD_0}{1 - \lambda\theta}, \quad \text{and} \quad dL = \lambda \frac{dD_0}{1 - \lambda\theta}. \tag{34}$$

To see how this equilibrium quantity of deposits and loans arises, consider the round-by-round balance sheet dynamics. Since no new outside reserves accompany the deposit inflow, the initial effect is a balance sheet expansion: the stable deposit dD_0 increases deposits and raises cash C one-for-one through the balance sheet identity. Because stable deposits are less runnable than wholesale funding, this inflow relaxes the bank's liquidity constraint, creating room for balance sheet expansion.

The bank responds by originating λdD_0 in new loans. When the bank lends, it simultaneously creates a new liability and the borrower's account is credited. This new liability is initially flighty, because the borrower may intend to spend the funds immediately. On impact, loans increase by λdD_0 and cash declines by the same amount, while wholesale funding adjusts endogenously according to its first-order condition. The original stable deposit dD_0 remains in place, backing higher cash holdings. It was not mechanically used to fund the loan; rather, it relaxed the regulatory constraints that made the bank willing to expand.[13]

As the borrowers spend the loan proceeds and the resulting payment flows circulate through

[13] An equivalent accounting decomposition is to view the deposit inflow dD_0 as partially funding the loan while wholesale adjusts residually. Both decompositions produce identical balance sheet outcomes. The interpretation adopted here emphasizes that the amplification mechanism operates through regulatory wedges and deposit recycling rather than a mechanical funding identity.

the economy, a fraction θ of the initially flighty liabilities settle into stable core deposits. This adds $\theta\lambda dD_0$ in stable funding to the banking system and increases cash correspondingly. The remaining $(1-\theta)\lambda dD_0$ remain outside the stable deposit base and do not support further expansion. The new stable deposits relax the liquidity constraint further, enabling the bank to originate another $\lambda^2\theta dD_0$ in loans, again creating flighty liabilities that partially stabilize through θ. The process continues with diminishing rounds, converging to the fixed point derived above.

It is worth highlighting that the roles of λ and θ are distinct in this mechanism. The parameter λ governs how much credit is created per dollar of stable deposits, but by itself generates no deposit amplification: if $\theta = 0$, lending creates balances that never settle as stable deposits, and total stable deposits remain dD_0. It is θ that converts the flighty liabilities created by lending into stable deposits, which in turn supports further lending. Both are necessary for the multiplier: λ without θ produces credit but no deposit amplification, while θ without λ provides nothing to recycle. Their interaction, summarized by the product $\lambda\theta$, determines the strength of the multiplier and the degree to which primitive shocks are amplified through the banking system.

4.7.4 Profits and the Multiplier at Longer Horizons

At longer horizons, profits generated by lending activity can amplify the credit-deposit multiplier through two additional channels. When borrowers use credit to finance production, they generate output Y and earn profits $\Pi = Y - wN - r^{\ell}L - r^{nb}L_{nb}$, while banks and nonbank lenders earn intermediation profits from interest spreads. These profits ultimately accrue to households as wages, dividends, and retained earnings, raising depositor wealth W_d and shifting out deposit demand. To the extent that bank profits are retained rather than distributed, they also raise bank equity E, relaxing the capital constraint and increasing the bank's willingness to expand its balance sheet.

The first channel operates through θ. Note that while the total pool of cash injected into the payment system by lending remains ΔL, higher household wealth W_d from positive profits shifts out deposit demand, increasing the fraction of circulating balances that households choose to hold as stable deposits, effectively raising θ. The second channel operates through λ. Retained bank profits raise equity E, which relaxes the capital constraint $K = E - \kappa(L + R)$ and lowers the shadow cost of balance sheet expansion, increasing the lending response λ in response to any given deposit inflow.

Both channels operate at business cycle frequency, since profits must be realized, distributed or retained, and reinvested before they affect deposit demand or bank equity, whereas the credit-deposit multiplier that we study propagates through bank balance sheets at a high frequency horizon over weeks. We therefore hold E fixed and evaluate θ at prevailing deposit demand conditions, so that the multiplier captures short-run balance sheet propagation in isolation.

The profit-driven amplification that we abstract from is closely related to the financial accelerator studied in the macro-finance literature (Bernanke et al., 1999; Gertler and Kiyotaki, 2010; He and Krishnamurthy, 2013), in which higher intermediary net worth relaxes borrowing constraints and enables further credit expansion. Our credit-deposit multiplier operates before and independently of this channel. At the same time, the two mechanisms would interact at longer horizons: profits raise depositor wealth and bank equity, which strengthen the credit-deposit feedback loop through both θ and λ, generating more lending and further profits.

5 Model Calibration

5.1 Data

We assemble an aggregate quarterly panel for the U.S. commercial banking sector combining Federal Reserve balance sheet quantities with FDIC Quarterly Banking Profile interest flows. All quantities are expressed relative to nominal GDP. The sample spans 1999Q1–2024Q4.

We measure core deposits, loans, wholesale funding, and equity using aggregate balance sheet data. Deposit and loan rates are constructed from interest flows and stocks. The policy rate is the effective federal funds rate. On the depositor side, money market funds and currency serve as liquid outside options; on the borrower side, nonbank credit is measured using corporate debt securities from the Financial Accounts. Details of variable construction are provided in Appendix A.4.

Table 4: Model Calibration

The table reports statutory parameters, calibrated preference parameters, and structural parameters estimated by GMM. Panel A lists statutory capital and liquidity parameters fixed by regulation. Panel B lists deposit and loan rate sensitivities. Panel C reports GMM estimates with standard errors in brackets. Panel D reports model-implied deposit multipliers with IV estimates.

Symbol	Description	Value	
Panel A: Statutory Parameters			
κ_{pre}	Capital requirement (pre)	0.020	
κ_{post}	Capital requirement (post)	0.080	
χ_{pre}	Liquidity ratio (pre)	0.150	
ψ_{pre}	Flightiness (pre)	0.300	
χ_{post}	Liquidity ratio (post)	0.350	
ψ_{post}	Flightiness (post)	0.600	
Panel B: Price Elasticities			
α_d	Depositors' rate sensitivity	1.270	
α_ℓ	Borrowers' rate sensitivity	5.560	
Panel C: Estimated Parameters (GMM)			
κ_W	Wholesale curvature	3.289 [1.236]	
τ	Liquidity wedge	0.106 [0.060]	
ξ	Capital wedge	0.557 [0.282]	
κ_{nb}^{pre}	Nonbank quadratic cost (pre)	4.966 [0.829]	
κ_{nb}^{post}	Nonbank quadratic cost (post)	2.358 [0.818]	
θ_{pre}	Recycling wedge (pre)	0.917 [0.073]	
θ_{post}	Recycling wedge (post)	0.725 [0.196]	
Panel D: Deposit Multipliers (Data vs Model)			
m_{pre}	Deposit multiplier (pre)	Model: 2.60	Data: 2.60
m_{post}	Deposit multiplier (post)	Model: 1.31	Data: 1.30
λ_{pre}	Deposit–loan amplification λ (pre)	Model: 0.665	
λ_{post}	Deposit–loan amplification λ (post)	Model: 0.323	

5.2 Demand Parameters

We discipline deposit and credit demand using aggregate market shares constructed from the quantity data. Depositors choose between bank deposits, money market funds, and currency, while borrowers choose between bank loans, market debt, and an outside option of not borrowing. Price elasticities are taken from the literature and imply standard markup formulas in the logit model. These objects map observed spreads into implied demand elasticities and are treated as inputs to the bank-side estimation. Finally, we discipline the recycling parameter θ using reduced-form estimates of the credit–deposit multiplier.

5.3 Calibrated Parameters

We display the calibrated parameters in Table 4. First, in Panel A, we display the statutory parameters that govern the regulatory regimes in the pre- and post-periods. We define the capital requirement to be 8% in the post-period. This is greater than the "well capitalized" level specified by the Supplementary Leverage Ratio (Koont and Walz, 2021) due to the fact that the capital measure here is the difference between assets and liabilities, which is a broader measure of capital compared to Tier 1 capital in the SLR. We assume a relatively unconstrained capital regime in the pre-period (e.g., $\kappa_{\text{pre}} = 0.02$).[14]

Next, we specify liquidity regimes in the pre- and post-periods. The parameter χ governs the required share of liquid assets relative to runnable funding, while ψ determines the fraction of deposits treated as runnable.[15] In the pre-reform regime, $(\chi\text{pre}, \psi\text{pre}) = (0.15, 0.30)$ imply a requirement equal to 15 percent of runnable funding, corresponding in the data to an average required buffer of roughly 9 percent of total assets; actual liquid assets average 21.7 percent of assets, leaving substantial liquidity slack. In the post-reform regime, $(\chi_{\text{post}}, \psi_{\text{post}}) = (0.35, 0.60)$ imply a requirement equal to 35 percent of runnable funding, corresponding to an average required buffer of 22.4 percent of assets; actual liquid assets average 25.8 percent of assets, leaving only 3.4 percent slack. The post-reform calibration therefore captures a pronounced tightening of effective liquidity requirements, with the required buffer relative to assets more than doubling and liquidity slack declining sharply. In the fixed-reserve version of the model, liquidity regulation operates by constraining the composition of funding relative to liquid assets rather than by requiring endogenous reserve accumulation; in the complete model, we allow non-reserve liquid assets to adjust, consistent with observed liquidity buffers.

Next, Panel B reports the asset-market elasticity parameters that discipline depositor supply and borrower demand, taken from the literature (Xiao, 2019; Diamond et al., 2024). These elasticities govern the responsiveness of deposits and loans to interest rates and therefore shape equilibrium funding pass-through and lending competition.[16]

Panel C presents the structural parameters estimated by just-identified GMM. The liquidity

[14]Note that the main capital regime in the pre-period was focused on risk-based capital requirements rather than simple leverage requirements, which became more binding in the post period (Walz, 2026). In this baseline version of the model we isolate the marginal increase in balance sheet costs rather than the effect of risk-based capital requirements which would be qualitatively similar.

[15]We plot the full quarterly series of the quantities Kt and Λt in Appendix Figure A.1.

[16]The exact values for these price elasticities do not qualitatively change the model.

slack parameter τ and the capital slack parameter ξ capture the marginal cost of operating close to statutory liquidity and capital requirements reported in Panel A.

The quadratic nonbank cost parameter declines, reflecting a lower marginal cost of nonbank credit provision in the later regime. We also estimate regime-specific recycling parameters. The recycling wedge falls from θ^{pre} to θ^{post}, implying substantially weaker deposit recycling in the post-period. Together, these parameters govern the strength of endogenous balance sheet amplification.

Panel D reports the model-implied deposit multipliers in the pre- and post-periods alongside their instrumental variable counterparts. The model produces a pre-period deposit multiplier of 2.60 and a post-period multiplier of 1.30, closely matching the empirical estimates. This alignment provides quantitative discipline for the estimated cost, slack, and recycling parameters. The calibration of lambda suggests that each deposit inflow produces about half of the initial credit impulse in the post period.

6 Quantitative Analysis

6.1 Multiplier Decomposition

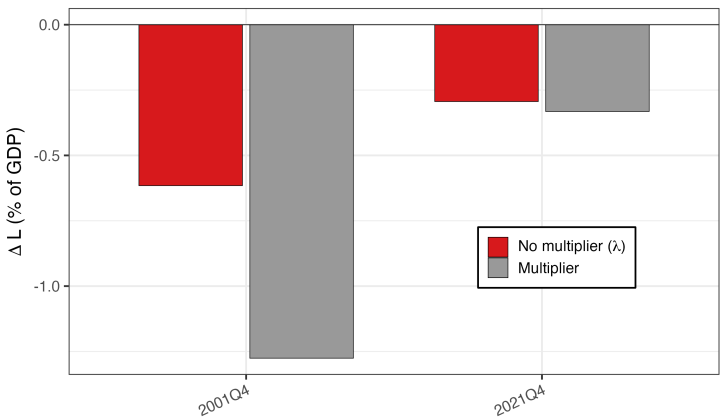
We use the calibrated model to decompose the decline in the deposit multiplier between 2001Q4 and 2021Q4. We use the calibrated model to quantify the importance of the credit–deposit multiplier in explaining changes in credit sensitivity over time. Figure 6 compares the credit impact of a one percent of GDP deposit outflow in 2001Q4 and 2021Q4.

The red bars report the first-round, on-impact response of bank lending. In the model this corresponds to the marginal pass-through parameter, $\Delta L = \lambda \Delta D$, abstracting from deposit recycling. The blue bars show the full credit effect once endogenous redepositing is taken into account, given by $m_L = \frac{\lambda}{1-\theta\lambda}$.

Two results stand out. First, first-round pass-through declines substantially between 2001Q4 and 2021Q4. Second, amplification through the multiplier is quantitatively important in 2001Q4, where recycling more than doubles the initial credit contraction. By 2021Q4, both marginal pass-through and multiplier strength are attenuated, substantially dampening the overall credit response to funding shocks.

Figure 6: First-Round and Total Credit Effects

The figure compares the first-round credit effect and the total credit effect of a one percent of GDP deposit outflow in 2001Q4 and 2021Q4. The first-round effect corresponds to the immediate change in total credit, $\lambda_{\text{total}}\Delta D$, holding deposits fixed and abstracting from recycling. The total effect incorporates full amplification through endogenous deposit re-depositing and multiplier dynamics, $m \times \lambda_{\text{total}}\Delta D$. Differences across periods reflect changes in both marginal pass-through and amplification strength.



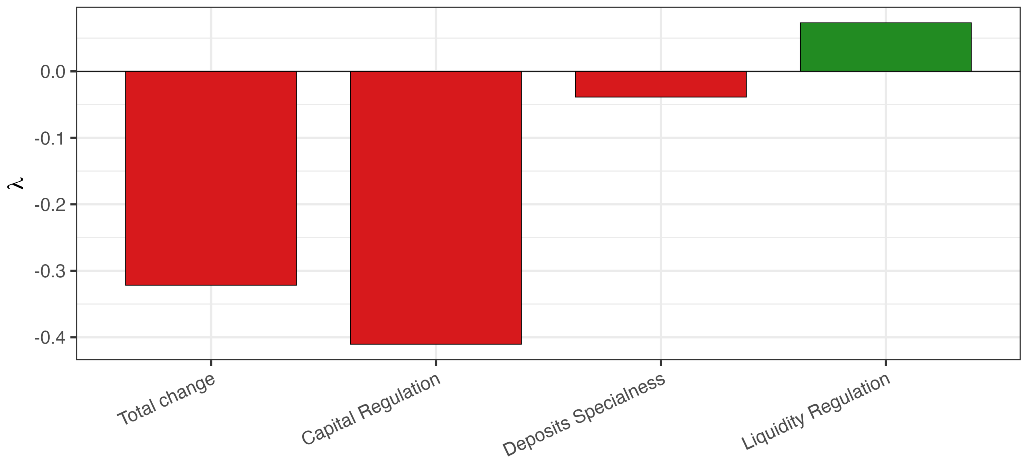
Next, we use the model to study the drivers of the decline in the credit impact of deposit flows. Figure 7 reports a sequential decomposition of the change from the 2001Q4 baseline to the 2021Q4 baseline. Starting from the 2001Q4 economy, we replace parameters one at a time with their post-regulation counterparts and report the marginal contribution of each substitution.

Panel (a) reports the pass-through parameter $\lambda = dL/dD$. λ declines from roughly 0.65 in 2001Q4 to about 0.32 in 2021Q4, a reduction of approximately 0.33. Tightening capital regulation more than accounts for this decline: moving to the post-regulation capital wedge reduces λ by roughly 0.40 on its own. Changes in deposit runnability further lower λ by about 0.05, reflecting a weaker funding advantage of deposits in the post period. In contrast, the post-regulation liquidity regime offsets part of the contraction, increasing λ by roughly 0.08–0.10 relative to the capital-only counterfactual. Stricter liquidity requirements reduce effective liquidity slack, increasing the sensitivity of lending to marginal funding shocks in the model.

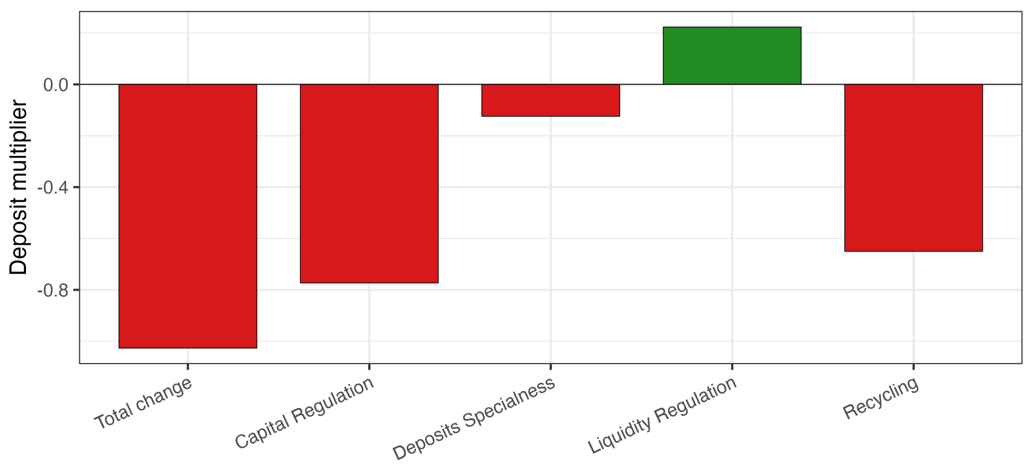
Panel (b) reports the deposit multiplier m. The multiplier falls from approximately 2.6 to 1.3, a decline of about 1.3. As with λ, tighter capital regulation explains more than the total observed reduction, lowering m by roughly 0.8 in isolation. Reduced deposit runnability contributes an additional decline of about 0.2. The post-regulation liquidity regime partially offsets these forces, raising the multiplier by roughly 0.2 relative to the capital and runnability adjust-

Figure 7: Decomposing Changes in λ and the Deposit Multiplier

Each panel reports a sequential decomposition of the change from the 2001Q4 baseline to the 2021Q4 baseline. The first bar shows the total change. The subsequent bars report the marginal contribution of sequentially substituting (i) capital regulation, (ii) deposit runnability (deposits specialness), and (iii) liquidity regulation. The multiplier in panel (b) also incorporates the influence of (iv) the recycling parameter, with each effect computed relative to the previous bar.



(a) λ

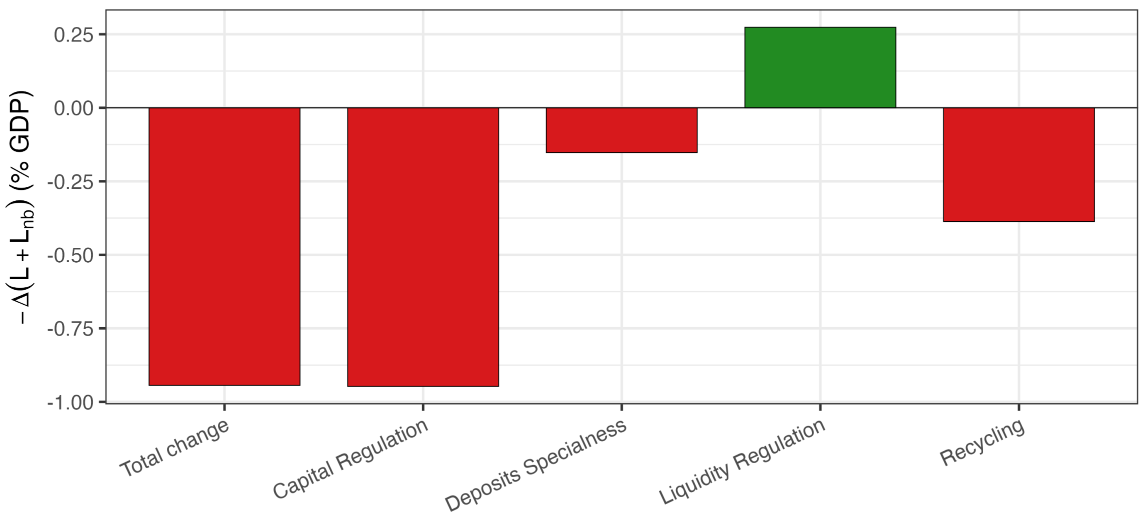


(b) Deposit multiplier m

ments. Finally, the decline in the recycling parameter θ lowers the multiplier by approximately 0.6. Economically, a lower recycling parameter reduces the fraction of loan-financed activity that returns as deposits, weakening the endogenous feedback loop that generates amplification.

Figure 8: Decomposing Changes in Total Credit

The figure reports a sequential decomposition of the change in total credit $\Delta(L + L_{\text{nb}})$ from the 2021Q4 baseline to the 2001Q4 baseline, following a one percent of GDP deposit outflow. The first bar shows the change in the effect of on deposits (e.g., the passthrough decreased by nearly 1 percentage point of GDP). The subsequent bars report the marginal change from reverting the 2021Q4 banking sector back to the following counterfactuals sequentially: (i) the pre-capital wedge, (ii) the pre-runnability parameter, (iii) the pre-liquidity requirement, and (iv) the pre-recycling parameter, with each effect computed relative to the previous bar.



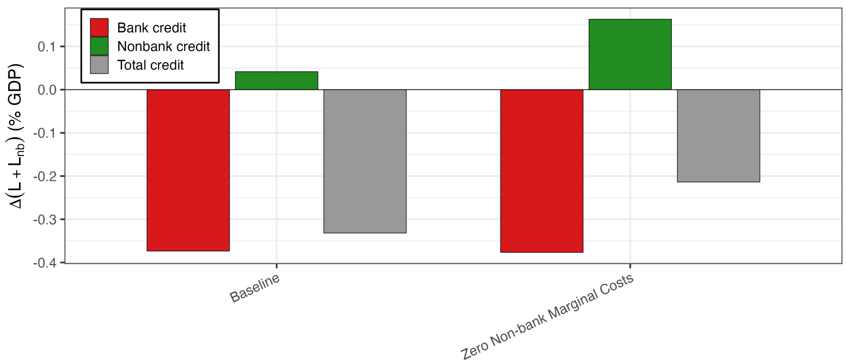
6.2 Effects on Total Credit

We next translate the multiplier decomposition into implications for aggregate credit. Figure 8 reports a sequential decomposition of the response of total credit $\Delta(L + L_{\text{nb}})$ to a one percent of GDP deposit outflow.

The first bar shows that a one-percentage-point deposit outflow reduces total credit by roughly one percentage point of GDP less in 2021Q4 than in 2001Q4, reflecting the decline in the amplification mechanism. The remaining bars decompose this change sequentially. Reverting capital regulation to its pre-2012 level accounts for the bulk of the difference, nearly restoring the stronger credit response observed in the earlier regime. Next, increasing the relative liquidity services of deposits (i.e., reverting the runnability parameter to its pre-2012 value) further strengthens the sensitivity of credit to deposit shocks. In contrast, replacing the post liquidity requirement with the pre-reform liquidity regime attenuates the contraction, consistent with greater liquidity slack dampening balance sheet adjustment. Finally, reverting the recycling parameter to its pre-2012 value amplifies the credit response, as stronger recycling increases the

Figure 9: Credit Response Under Alternative Nonbank Competition

Model-implied responses of bank, nonbank, and total credit to a one-percent-of-GDP deposit outflow at the 2021Q4 equilibrium. The baseline reflects the calibrated post-regulation economy. In the counterfactual we shut down non-bank marginal costs κ_{nb} by setting it to 0.



propagation of the initial deposit outflow through endogenous funding feedback. A residual term captures differences in steady-state balance sheet conditions across the two periods.

6.2.1 When Do Non-banks Offset Banks?

Figure 9 studies the how the competitive forces in the non-bank sector can offset changes in bank lending following a deposit shock. The figure reports the model-implied responses of bank loans, nonbank loans, and total credit to a one percent of GDP deposit outflow, evaluated at the 2021Q4 equilibrium.

In the baseline, a one percent of GDP deposit outflow reduces bank lending by roughly 0.35 percent of GDP. Non-bank lending rises modestly, but the increase is small relative to the contraction in bank credit, so total credit declines by just over 0.3 percent of GDP. Non-banks therefore offset only a limited fraction of the bank contraction in the calibrated post-regulation economy.

Setting nonbank marginal costs to zero strengthens the nonbank response and the decline in total credit is attenuated. Economically, this arises because non-banks no longer face costly decreasing returns to scale. However, even in this extreme case, non-banks do not fully offset banks. The reason is that borrowers retain an outside option, so part of the adjustment occurs along the extensive margin between credit and the outside alternative rather than entirely between bank and nonbank credit. The remaining effects on total credit result from borrowers substituting into the outside option of not borrowing.

7 Conclusion

This paper quantifies how bank deposit creation has changed over time and what that implies for macro transmission. Using plausibly exogenous shocks to depositor wealth, we document a pronounced decline in the credit–deposit feedback: before the financial crisis, each dollar of external deposits ultimately generated more than three dollars of total deposits; by the 2020s, the multiplier is close to one.

We interpret these facts using a structural model in which deposit creation arises from the joint determination of deposits and loans under capital and liquidity requirements. The model attributes the decline in the multiplier to tighter balance sheet constraints and to a shrinking share of deposits intermediated by banks, rather than to changes in any exogenous market size. In our framework, three sufficient statistics summarize this amplification channel: the bank share on the funding side, the responsiveness of lending to marginal deposits, and the extent to which new deposits expand bank assets rather than substituting for other funding sources. All three emerge endogenously from regulatory slacks and portfolio composition. Counterfactuals that relax capital or liquidity wedges or increase banks' funding share materially strengthen the multiplier, while policies that reduce banks' footprint weaken it. The model also delivers asymmetric responses: equal-sized inflows and outflows of deposits generate different lending effects because the shadow value of funding is state dependent.

The continued growth of non-bank intermediation, such as the rise of stablecoins, would further attenuate both the banking multiplier and the economy-wide multiplier, since a smaller share of funding would pass through the banking sector's amplification mechanism. This highlights that reallocating money from banks to non-banks is not neutral: as banks become a smaller part of the financial system, deposit and credit creation become less responsive to underlying shocks. Conversely, looser capital requirements combined with liquidity regulation that further favors deposit funding would increase the equilibrium degree of credit amplification. Taken together, our results show that the behavior of the credit–deposit multiplier, and therefore the transmission of both monetary and fiscal policy, depends critically on the competitive and regulatory structure of the banking sector and on banks' role in creating deposits.

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Appendix A.1 Simple Example: Reserve-Creation and Cash Management

Table A.1: Simple Example with Reserve Creation: Credit-Deposit Multiplier

Initial

Assets		Liabilities	
R	\$100	W	\$100
	\$100		\$100

Deposit Inflow + Reserves

Assets		Liabilities	
R	\$200	D	\$100
		W	\$100
	\$200		\$200

Loan Origination

Assets		Liabilities	
R	\$200	D	\$100
L	\$70	W	\$170
	\$270		\$270

Deposit Recycling

Assets		Liabilities	
R	\$200	D	\$163
L	\$70	W	\$107
	\$270		\$270

Loan Origination

Assets		Liabilities	
R	\$200	D	\$163
L	\$114	W	\$151
	\$314		\$314

The deposit inflow is accompanied by an equal increase in reserves (e.g., Treasury spending that credits deposits and reserves). The banking sector expands lending by $\lambda = 0.7$ per dollar of stable deposits, creating flighty funding (modeled as wholesale liabilities) alongside the new loans. A fraction $\theta = 0.9$ of flighty balances is retained as stable deposits, raising deposits and initiating the next round.

Table A.2: Aggregate Banking System with Reserve-backed Inflow: Incremental Expansion by Round

Round	**Reserves**	**Deposits**	**Loans**
Initial Inflow	\$100.0	\$100.0	\$0.0
Lending	\$0.0	\$0.0	\$70.0
Round 2	\$0.0	\$63.0	\$44.1
Round 3	\$0.0	\$39.7	\$27.8
Round 4	\$0.0	\$25.0	\$17.5
Total (Limit)	**\$100.0**	**\$270.3**	**\$189.2**

The initial deposit inflow is accompanied by an equal reserve injection (e.g., Treasury spending that credits deposits and reserve balances). Incremental lending equals $\lambda = 0.7$ times newly retained deposits, and newly retained deposits equal to $\theta = 0.9$ times the previous round's lending. Successive rounds shrink by the factor $\lambda\theta = 0.63$, and totals converge.

Table A.3: Simple Example Cash Adjustment: Credit-Deposit Multiplier

Initial

Assets		Liabilities	
R	$50	W	$50
C	$50	D	$50
	$100		$100

Deposit Inflow + Reserves

Assets		Liabilities	
R	$150	D	$150
C	$50	W	$50
	$200		$200

Balance Sheet Adjustment

Assets		Liabilities	
R	$150	D	$150
C	$25	W	$25
	$175		$175

Loan Origination

Assets		Liabilities	
R	$150	D	$150
C	$25	W	$95
L	$70		
	$245		$245

Deposit Recycling

Assets		Liabilities	
R	$150	D	$213
C	$25	W	$32
L	$70		
	$245		$245

Balance Sheet Adjustment

Assets		Liabilities	
R	$150	D	$213
C	$12	W	$19
L	$70		
	$232		$232

Loan Origination

Assets		Liabilities	
R	$150	D	$213
C	$12	W	$63
L	$114		
	$276		$276

The initial deposit inflow is accompanied by an equal reserve injection. The banking sector then partially unwinds the inflow by reducing its liquid asset buffer C and retiring wholesale funding. Lending expands loans by $\lambda = 0.7$ per dollar of newly retained deposits, creating flighty funding (modeled as wholesale liabilities). A fraction $\theta = 0.9$ of loan-generated flighty balances is retained as stable deposits, raising deposits and initiating the next round.

Table A.4: Aggregate Banking System with Cash Adjustment: Incremental Expansion by Round

Round	**Reserves**	**Cash**	**Deposits**	**Loans**
Initial Inflow	\$100.0	\$0.0	\$100.0	\$0.0
Cash Adjustment	\$0.0	\$-25.0	\$0.0	\$0.0
Lending	\$0.0	\$0	\$0.0	\$70.0
Round 2	\$0.0	\$-12.5	\$63.0	\$44.1
Round 3	\$0.0	\$-6.3	\$39.7	\$27.8
Round 4	\$0.0	\$-3.1	\$25.0	\$17.5
Total (Limit)	**\$100.0**	**\$-50.0**	**\$270.3**	**\$189.2**

The initial deposit inflow is accompanied by an equal reserve injection. The banking sector then partially unwinds liquid asset holdings by reducing cash C and retiring wholesale funding. Loans equals $\lambda = 0.7$ times newly retained deposits, and newly retained deposits equal to $\theta = 0.9$ times the previous round's lending. Successive rounds shrink by the factor $\lambda\theta = 0.63$, and totals converge.

Appendix A.2 Model Derivation

A.2.1 Bank First Order Conditions

The representative banking sector chooses the loan rate r^ℓ, the deposit rate r^d, and wholesale funding W to maximize

$$\Pi = (r^\ell - r^S)L(r^\ell) \;+\; (r^S - r^d)D(r^d) \;-\; \frac{\kappa_W}{2}W^2 \;+\; \xi \ln\bigl(K\bigr) \;+\; \tau \ln\bigl(\Lambda\bigr), \tag{1}$$

taking r^S and equity E as given. Re-writing the capital and liquidity slack in terms of choice variables of the bank. Using the balance sheet identity

$$L + R = E + D + W \qquad \Rightarrow \qquad R = E + D + W - L, \tag{2}$$

we can substitute out reserves in the liquidity slack:

$$K \;=\; (1-\kappa)E \;-\; \kappa(D + W), \tag{3}$$

$$\begin{aligned} \Lambda &= R - \chi(\psi D + W) \\ &= \bigl(E + D + W - L\bigr) - \chi(\psi D + W) \\ &= E - L + (1 - \chi\psi)D + (1 - \chi)W. \end{aligned} \tag{4}$$

A.2.1.1 First Order Conditions

Using (3) and (4), the bank chooses (r^ℓ, r^d, W) taking (r^S, E) as given.

A.2.1.2 Loan Rate r^ℓ

Differentiating profits with respect to r^ℓ yields

$$0 = \frac{\partial \Pi}{\partial r^\ell} = (r^\ell - r^S)\frac{dL}{dr^\ell} + L + \tau \frac{1}{\Lambda}\frac{\partial \Lambda}{\partial L}\frac{dL}{dr^\ell}. \tag{5}$$

From (4), $\frac{\partial \Lambda}{\partial L} = -1$, so

$$0 = (r^\ell - r^S)\frac{dL}{dr^\ell} + L - \frac{\tau}{\Lambda}\frac{dL}{dr^\ell}, \tag{6}$$

which implies

$$r_\ell = r_S - \frac{L}{\frac{dL}{dr^\ell}} + \frac{\tau}{\Lambda}. \tag{7}$$

Under logit loan demand, $\frac{dL}{dr^\ell} = -\alpha_\ell(1 - s_\ell)L$, so the loan pricing equation is

$$r_\ell = r_S + \frac{1}{\alpha_\ell(1 - s_\ell)} + \frac{\tau}{\Lambda}. \tag{8}$$

A.2.1.3 Deposit Rate r^d

Differentiating profits with respect to r^d yields

$$0 = \frac{\partial \Pi}{\partial r^d} = (r^S - r^d)\frac{dD}{dr^d} - D + \xi\frac{1}{K}\frac{\partial K}{\partial D}\frac{dD}{dr^d} + \tau\frac{1}{\Lambda}\frac{\partial \Lambda}{\partial D}\frac{dD}{dr^d}. \tag{9}$$

From (3), $\frac{\partial K}{\partial D} = -\kappa$, and from (4), $\frac{\partial \Lambda}{\partial D} = 1 - \chi\psi$, so

$$0 = (r^S - r^d)\frac{dD}{dr^d} - D - \kappa\frac{\xi}{K}\frac{dD}{dr^d} + (1 - \chi\psi)\frac{\tau}{\Lambda}\frac{dD}{dr^d}, \tag{10}$$

which implies

$$r_d = r_S - \frac{D}{\frac{dD}{dr^d}} - \kappa\frac{\xi}{K} + (1 - \chi\psi)\frac{\tau}{\Lambda}. \tag{11}$$

Under logit deposit demand, $\frac{dD}{dr^d} = \alpha_d(1 - s_d)D$, so the deposit pricing equation is

$$r_d = r_S - \frac{1}{\alpha_d(1 - s_d)} - \kappa\frac{\xi}{K} + (1 - \chi\psi)\frac{\tau}{\Lambda}. \tag{12}$$

A.2.1.4 Wholesale Funding W

Differentiating profits with respect to W yields

$$0 = \frac{\partial \Pi}{\partial W} = -\kappa_W W + \xi \frac{1}{K} \frac{\partial K}{\partial W} + \tau \frac{1}{\Lambda} \frac{\partial \Lambda}{\partial W}. \tag{13}$$

From (3), $\frac{\partial K}{\partial W} = -\kappa$, and from (4), $\frac{\partial \Lambda}{\partial W} = 1 - \chi$, so

$$0 = -\kappa_W W - \kappa \frac{\xi}{K} + (1-\chi)\frac{\tau}{\Lambda}. \tag{14}$$

Equivalently, the wholesale funding condition is

$$\kappa_W W = \frac{(1-\chi)\tau}{\Lambda} - \frac{\kappa \xi}{K}. \tag{15}$$

A.2.2 Derivation of $\lambda = \dfrac{dL}{dD}$

In this section we derive the pass-through

$$\lambda = \frac{dL}{dD},$$

the change in bank lending L generated by a marginal change in deposits D, evaluated at the equilibrium of the model. Three ingredients determine λ: the balance sheet identity, the capital and liquidity identities, and the joint bank–nonbank pricing system. We study small shocks around an interior equilibrium

$$x^* = (r_d^*, r_\ell^*, r_{nb}^*, R^*, W^*, D^*, L^*, L_{nb}^*),$$

in which capital slack $K > 0$, liquidity slack $\Lambda > 0$, wholesale funding $W > 0$, and all market shares lie strictly between zero and one. Because the equilibrium is interior and the system of pricing conditions, demand equations, and balance sheet identities is locally well behaved, small shocks to exogenous drivers induce well-defined local co-movements among the endogenous variables. We therefore take total differentials of the equilibrium system and solve for the implied linear relations among

$$(d\Lambda, dK, dR, dL, dD, dW, dr_d, dr_\ell, dr_{nb}, dL_{nb}).$$

The key equilibrium conditions are:

$$
\begin{aligned}
L + R &= E + D + W, && \text{(balance sheet identity)} \quad (16)\\
\Lambda &= R - \chi(\psi D + W), && \text{(liquidity identity)} \quad (17)\\
K &= (1-\kappa)E - \kappa(D + W), && \text{(capital identity)} \quad (18)\\
\kappa_W W &= \frac{\tau(1-\chi)}{\Lambda} - \frac{\xi\kappa}{K}, && \text{(wholesale FOC)} \quad (19)\\
r_\ell &= r_S + \frac{1}{\alpha^\ell(1-s_\ell)} + \frac{\tau}{\Lambda}, && \text{(bank loan pricing)} \quad (20)\\
r_d &= r_S - \frac{1}{\alpha_d(1-s_d)} + \chi(1-\psi)\frac{\tau}{\Lambda} - \kappa\frac{\xi}{K}, && \text{(bank deposit pricing)} \quad (21)\\
r_{nb} &= r_S + \kappa_{nb} L_{nb} + \frac{1}{\alpha^\ell(1-s_{nb})}, && \text{(non-bank pricing)} \quad (22)
\end{aligned}
$$

In this general version, equity E is treated as fixed, so $dE = 0$ in the comparative statics below, while reserves R adjusts endogenously through (16). Differentiating Λ produces

$$
\begin{aligned}
d\Lambda &= (dD + dW - dL) - \chi(\psi dD + dW)\\
&= -\,dL + (1-\chi\psi)\,dD + (1-\chi)\,dW. \qquad (23)
\end{aligned}
$$

Loan expansion tightens liquidity through its effect on reserve holdings, while deposits relax liquidity to the extent that they are less runnable than wholesale funding ($\psi < 1$). Differentiating the capital identity (18) gives

$$dK = -\kappa(dD + dW). \qquad (24)$$

Intuitively, expanding liabilities reduces capital slack in proportion to κ. With non-bank credit, bank loan demand depends on both loan rates, $L = L(r_\ell, r_{nb})$, and the non-bank loan rate r_{nb} is pinned down by (22). We therefore differentiate the two pricing conditions (20)–(22) jointly and use logit semi-elasticities to express dL as a function of $(dW, d\Lambda, dK)$. Differentiating (20) gives

$$dr_\ell = \frac{1}{\alpha^\ell}\frac{1}{(1-s_\ell)^2}\,ds_\ell - \frac{\tau}{\Lambda^2}\,d\Lambda. \qquad (25)$$

Differentiating our logit demand functions we have

$$ds_\ell = -\alpha^\ell s_\ell(1 - s_\ell)\, dr_\ell + \alpha^\ell s_\ell s_{nb}\, dr_{nb}. \tag{26}$$

Next we substitute (26) into (25) to yield

$$dr_\ell = \frac{s_\ell s_{nb}}{1 - s_\ell}\, dr_{nb} - (1 - s_\ell)\frac{\tau}{\Lambda^2}\, d\Lambda. \tag{27}$$

Differentiating (22) gives

$$dr_{nb} = \kappa_{nb}\, dL_{nb} + \frac{1}{\alpha^\ell}\frac{1}{(1 - s_{nb})^2}\, ds_{nb}. \tag{28}$$

Using logit semi-elasticities,

$$dL_{nb} = -\alpha^\ell(1 - s_{nb})L_{nb}\, dr_{nb} + \alpha^\ell s_\ell L_{nb}\, dr_\ell, \tag{29}$$

$$ds_{nb} = -\alpha^\ell s_{nb}(1 - s_{nb})\, dr_{nb} + \alpha^\ell s_{nb} s_\ell\, dr_\ell, \tag{30}$$

and substituting (29)–(30) into (28) implies

$$\Big(1 + \kappa_{nb}\alpha^\ell(1 - s_{nb})L_{nb} + \frac{s_{nb}}{1 - s_{nb}}\Big)dr_{nb} = s_\ell\Big(\kappa_{nb}\alpha^\ell L_{nb} + \frac{s_{nb}}{(1 - s_{nb})^2}\Big)dr_\ell. \tag{31}$$

Finally, bank loan demand satisfies

$$dL = -\alpha^\ell(1 - s_\ell)L\, dr_\ell + \alpha^\ell s_{nb} L\, dr_{nb}. \tag{32}$$

Combining (27), (31), and (32) yields

$$dL = -\,\tilde{\kappa}_\ell^{nb}\Big(-\frac{\tau}{\Lambda^2}\, d\Lambda\Big), \tag{33}$$

where the non-bank-adjusted loan semi-elasticity $\tilde{\kappa}_\ell^{nb} > 0$ is given explicitly by

$$\tilde{\kappa}_\ell^{nb} = \alpha^\ell L(1-s_\ell)^2 \\ \times \frac{(1-s_\ell)\Big(1+\kappa_{nb}\alpha^\ell(1-s_{nb})L_{nb}+\frac{s_{nb}}{1-s_{nb}}\Big) - \ s_\ell s_{nb}\Big(\kappa_{nb}\alpha^\ell L_{nb}+\frac{s_{nb}}{(1-s_{nb})^2}\Big)}{(1-s_\ell)\Big(1+\kappa_{nb}\alpha^\ell(1-s_{nb})L_{nb}+\frac{s_{nb}}{1-s_{nb}}\Big) - \ s_\ell^2 s_{nb}\Big(\kappa_{nb}\alpha^\ell L_{nb}+\frac{s_{nb}}{(1-s_{nb})^2}\Big)}. \tag{34}$$

When $s_{nb} = 0$ (or the non-bank rate is fixed), the fraction in (34) equals one and (33) reduces to the banking-sector-only response. Note that by using this term the bank considers their own price and cross price elasticity. We now substitute the liquidity differential (23) and the wholesale-optimality condition into the linearized loan-demand relation (33) to solve for the pass-through $\lambda \equiv \dfrac{dL}{dD}$.

From (33) and (33)–(25), we have

$$dL = -\,\tilde{\kappa}_\ell^{nb}\Big(-\frac{\tau}{\Lambda^2}\,d\Lambda\Big) = \tilde{\kappa}_\ell^{nb}\,\frac{\tau}{\Lambda^2}\,d\Lambda, \tag{35}$$

so that

$$d\Lambda = \frac{\Lambda^2}{\tau}\,\frac{1}{\tilde{\kappa}_\ell^{nb}}\,dL. \tag{36}$$

Next, differentiating the wholesale FOC (19) implies

$$\kappa_W\,dW = -\frac{\tau(1-\chi)}{\Lambda^2}\,d\Lambda + \frac{\xi\kappa}{K^2}\,dK. \tag{37}$$

Using (24) to substitute $dK = -\kappa(dD + dW)$ into (37) yields

$$\Big(\kappa_W + \frac{\xi\kappa^2}{K^2}\Big)dW = -\frac{\tau(1-\chi)}{\Lambda^2}\,d\Lambda - \frac{\xi\kappa^2}{K^2}\,dD. \tag{38}$$

Substituting (36) and rearranging produces

$$dW = -\frac{(1-\chi)}{\kappa_W + \frac{\xi\kappa^2}{K^2}}\,\frac{1}{\tilde{\kappa}_\ell^{nb}}\,dL - \frac{1}{\kappa_W + \frac{\xi\kappa^2}{K^2}}\,\frac{\xi\kappa^2}{K^2}\,dD. \tag{39}$$

Finally, substitute (39) into the liquidity differential (23), and use (36) to eliminate $d\Lambda$:

$$\begin{aligned}\frac{\Lambda^2}{\tau}\frac{1}{\tilde{\kappa}_\ell^{nb}}dL &= -\,dL + (1-\chi\psi)\,dD + (1-\chi)\,dW \\ &= -\,dL + (1-\chi\psi)\,dD + (1-\chi)\Big(-\frac{(1-\chi)}{\kappa_W + \frac{\xi\kappa^2}{K^2}}\frac{1}{\tilde{\kappa}_\ell^{nb}}\,dL - \frac{1}{\kappa_W + \frac{\xi\kappa^2}{K^2}}\frac{\xi\kappa^2}{K^2}\,dD\Big).\end{aligned} \tag{40}$$

Collecting dL and dD terms and solving for $\lambda = \dfrac{dL}{dD}$ yields

$$\lambda = \frac{dL}{dD} = \frac{\frac{\tau}{\Lambda^2}\,\tilde{\kappa}_\ell^{nb}\left[(1-\chi\psi)\ -\ (1-\chi)\,\frac{\frac{\xi\kappa^2}{K^2}}{\kappa_W+\frac{\xi\kappa^2}{K^2}}\right]}{1+\frac{\tau}{\Lambda^2}\tilde{\kappa}_\ell^{nb}+\frac{\tau(1-\chi)^2}{\Lambda^2\left(\kappa_W+\frac{\xi\kappa^2}{K^2}\right)}}. \tag{41}$$

A.2.3 Derivation of $\mathcal{W}_D = \dfrac{dW}{dD}$

We can start with the differential form of $d\Lambda$

$$d\Lambda = (1-\chi\psi)\,dD + (1-\chi)\,dW - dL. \tag{42}$$

Next differentiate the wholesale FOC,

$$\kappa_W W = \frac{(1-\chi)\tau}{\Lambda} - \frac{\kappa\xi}{K}, \tag{43}$$

to get

$$\kappa_W\,dW = -(1-\chi)\tau\,\frac{1}{\Lambda^2}\,d\Lambda + \kappa\xi\,\frac{1}{K^2}\,dK. \tag{44}$$

Substituting into (44) yields

$$\left(\kappa_W + \frac{\xi\kappa^2}{K^2}\right)dW = -(1-\chi)\tau\,\frac{1}{\Lambda^2}\,d\Lambda - \frac{\xi\kappa^2}{K^2}\,dD. \tag{45}$$

Now impose the definition $\lambda \equiv dL/dD$ and rewrite (42) as

$$d\Lambda = \Big[(1-\chi\psi) - \lambda\Big]\, dD + (1-\chi)\, dW. \tag{46}$$

Substituting (46) into (45) gives

$$\begin{aligned} \left(\kappa_W + \frac{\xi\kappa^2}{K^2}\right) dW &= -(1-\chi)\tau\,\frac{1}{\Lambda^2}\Big(\big[(1-\chi\psi)-\lambda\big]\, dD + (1-\chi)\, dW\Big) - \frac{\xi\kappa^2}{K^2}\, dD \\ \Rightarrow \quad \left(\kappa_W + \frac{\xi\kappa^2}{K^2} + \frac{\tau(1-\chi)^2}{\Lambda^2}\right) dW &= -\left(\frac{\tau(1-\chi)}{\Lambda^2}\big[(1-\chi\psi)-\lambda\big] + \frac{\xi\kappa^2}{K^2}\right) dD. \end{aligned} \tag{47}$$

Dividing by dD yields the compact expression

$$\mathcal{W}_D \;\equiv\; \frac{dW}{dD} = -\frac{\frac{\tau(1-\chi)}{\Lambda^2}\big[(1-\chi\psi)-\lambda\big] + \frac{\xi\kappa^2}{K^2}}{\kappa_W + \frac{\xi\kappa^2}{K^2} + \frac{\tau(1-\chi)^2}{\Lambda^2}}. \tag{48}$$

A.2.4 Derivation of $\lambda = \dfrac{dL}{dD}$ under $dR = 0$

We next derive λ in a model where reserves are fixed at the margin. Equity E is treated as fixed, so $dE = 0$. The key equilibrium conditions are

$$L + R = E + D + W, \tag{49}$$

$$\Lambda = R - \chi(\psi D + W), \tag{50}$$

$$K = (1-\kappa)E - \kappa(D + W). \tag{51}$$

Taking total differentials of the balance sheet identity and using $dR = 0$ yields

$$dL = dD + dW, \tag{52}$$

so that

$$dW = dL - dD. \tag{53}$$

Differentiating the liquidity identity and using $dR = 0$ gives

$$d\Lambda = -\,\chi(\psi\, dD + dW). \tag{54}$$

Substituting $dW = dL - dD$ implies

$$d\Lambda = -\chi\Big(dL + (\psi - 1)dD\Big). \tag{55}$$

Differentiating the capital identity and using (52) yields

$$dK = -\kappa(dD + dW) = -\kappa dL. \tag{56}$$

The linearized joint bank–nonbank pricing system implies

$$dL = -\tilde{\kappa}_{\ell}^{nb}\Big(\kappa_W dW - \chi\frac{\tau}{\Lambda^2}d\Lambda - \kappa\frac{\xi}{K^2}dK\Big). \tag{57}$$

Substituting $dW = dL - dD$, (55), and (56) into (57) gives

$$\begin{aligned}\kappa_W dW - \chi\frac{\tau}{\Lambda^2}d\Lambda - \kappa\frac{\xi}{K^2}dK &= \kappa_W(dL - dD) - \chi\frac{\tau}{\Lambda^2}\Big(-\chi(dL + (\psi-1)dD)\Big) - \kappa\frac{\xi}{K^2}(-\kappa dL) \\ &= \Big(\kappa_W + \frac{\tau\chi^2}{\Lambda^2} + \frac{\xi\kappa^2}{K^2}\Big)dL - \Big(\kappa_W - \frac{\tau\chi^2}{\Lambda^2}(\psi - 1)\Big)dD. \end{aligned} \tag{58}$$

Substituting back into (57) and collecting terms yields

$$dL = -\tilde{\kappa}_{\ell}^{nb}\Big[\Big(\kappa_W + \frac{\tau\chi^2}{\Lambda^2} + \frac{\xi\kappa^2}{K^2}\Big)dL - \Big(\kappa_W - \frac{\tau\chi^2}{\Lambda^2}(\psi - 1)\Big)dD\Big]. \tag{59}$$

Solving for $\lambda = \dfrac{dL}{dD}$ gives

$$\lambda = \frac{\kappa_W + \dfrac{\tau\chi^2}{\Lambda^2}(1-\psi)}{\dfrac{1}{\tilde{\kappa}_{\ell}^{nb}} + \kappa_W + \dfrac{\tau\chi^2}{\Lambda^2} + \dfrac{\xi\kappa^2}{K^2}}. \tag{60}$$

Now we can also solve for wholesale funding adjustments. With reserves R fixed, the differential for the balance sheet identity is

$$dW = dL - dD. \tag{61}$$

Dividing both sides of (61) by dD gives

$$\begin{aligned}\mathcal{W}_D \;\equiv\; \frac{dW}{dD} &= \frac{dL}{dD} - 1 \\ &= \lambda - 1. \end{aligned} \tag{62}$$

Thus, when reserves are fixed, wholesale funding adjusts residually to satisfy the balance sheet identity.

Appendix A.3 Do Non-Bank Liabilities Generate a Multiplier?

Table A.5: Non-Bank Funding Multiplier

(a) Funding Inflows Relax Non-Bank Balance Sheet Constraints

Funding Inflow

A		**L**	
Cash	$100	CP	$100
	$100		$100

Asset Purchase

A		**L**
Treasuries	$100	CP $100
	$100	$100

Funding Creation

A		**L**	
Treasuries	$100	CP	$100
Cash	$90	Repo	$90
	$190		$190

(b) Funding Inflows, Portfolio Rebalancing, and Amplification

Nonbank

A		**L**	
Treasuries	$100	Shares	$100
	$100		$100

Investor Sells

A		**L**
- Treasuries	$100	
+ Cash	$100	

Investor Rebalances

A		**L**
+ Treasuries	$50	
+ Shares	$50	
- Cash	$100	

Having established the link between deposits and bank credit, and the forces that give rise to a credit-deposit multiplier, it is useful to consider how these mechanisms differ for non-bank institutions.

Like a bank, a non-bank institution can expand its balance sheet by issuing non-bank liabilities, such as commercial paper, repo, or shares. Such expansions may arise either from shifts in demand for non-bank liabilities or from shifts in their supply, for example in response to new profitable investment opportunities. Whether such an increase in non-bank funding generates a multiplier depends on the extent to which non-bank claims are treated as money-like and whether they relax funding constraints. One case in which a multiplier can arise is when non-bank funding inflows are used to purchase assets that can be used as collateral to obtain additional funding, for example through repo transactions, as documented in panel (a) of Table A.5. Another channel through which a non-bank funding multiplier can arise is portfolio rebalancing by investors when non-banks purchase assets in response to funding inflows, which in equilibrium can increase demand for non-bank funding and generate amplification, as in panel (b) of Table A.5.

While non-bank balance sheet amplification can give rise to funding multipliers under certain conditions, such multipliers are likely to be weaker in practice, reflecting the unique role of deposits as the settlement asset. We therefore focus on banks' credit-deposit multiplier and abstract from non-bank multipliers.

Appendix A.4 Data Construction

This appendix describes the construction of the aggregate quantity and price series used in the calibration and estimation of the model.

We assemble a quarterly panel for the U.S. commercial banking sector spanning 1999Q1 to 2024Q4. Balance sheet quantities are obtained from the Federal Reserve's weekly series for all commercial banks, including total assets, total liabilities, total loans, total deposits, and large time deposits. Weekly observations are converted to quarterly frequency by taking the last available observation within each calendar quarter. Core deposits are defined as total deposits net of large time deposits. Wholesale funding is defined as total liabilities net of core deposits. Equity is constructed residually as the difference between assets and liabilities.

Deposit and loan rates are constructed using interest income and expense data from the FDIC Quarterly Banking Profile (QBP). Specifically, deposit and loan rates are measured as annualized ratios of trailing four-quarter interest flows to trailing four-quarter average stocks. Using trailing windows smooths high-frequency variation in flows and ensures comparability with the quarterly balance sheet quantities. The policy rate is measured by the effective federal funds rate, averaged over the same trailing four-quarter window.

Market credit rates are measured using Moody's Baa corporate bond yields. On the borrower side, nonbank credit is proxied by the stock of outstanding U.S. corporate debt securities from the Financial Accounts of the United States. On the depositor side, money market fund assets and currency in circulation are used as alternatives to deposits. All quantities are scaled by nominal GDP to create consistent time series.

Regulatory quantities entering the model are constructed from aggregate balance sheet objects and statutory capital requirements. Capital slack and liquidity slack are computed as functions of equity, loans, core deposits, and wholesale funding, and therefore vary endogenously over time with the evolution of bank balance sheets.

Appendix A.5 Demand System Details

This appendix provides additional details on the construction of market sizes, market shares, and demand objects used in the calibration.

On the depositor side, the market size in quarter t is defined as

$$W_t^d \equiv D_t + M_t + C_t,$$

where D_t denotes core deposits, M_t denotes money market fund assets, and C_t denotes currency in circulation. Depositor market shares are given by $s_t^d \equiv D_t/W_t^d$, $s_t^M \equiv M_t/W_t^d$, and $s_t^C \equiv C_t/W_t^d$.

On the borrower side, bank credit is measured by aggregate bank loans L_t, and nonbank credit is measured by the stock of outstanding corporate debt securities $L_{nb,t}$. To allow for an outside option of not borrowing, total borrower market size is defined as

$$W_t^b \equiv \eta_b(L_t + L_{nb,t}),$$

where $\eta_b > 1$ pins down the average share of non-borrowers. Borrower market shares are $s_t^L \equiv L_t/W_t^b$ and $s_t^{nb} \equiv L_{nb,t}/W_t^b$, with the no-borrowing share given by $s_t^0 \equiv 1 - s_t^L - s_t^{nb}$.

Both depositor and borrower demand systems are modeled as multinomial logit. Given price sensitivities α_d and α_ℓ, observed market shares map into implied elasticities and markups according to standard logit formulas. In particular, observed deposit spreads correspond to markups of $1/\{\alpha_d(1 - s_t^d)\}$, while observed loan spreads correspond to markups of $1/\{\alpha_\ell(1 - s_t^L)\}$.

Appendix A.6 GMM Estimation

This appendix describes the Generalized Method of Moments (GMM) procedure used to estimate the supply-side parameters of the model.

We estimate the parameter vector

$$\Theta \equiv \{ \tau, \xi, \kappa_{nb}^{pre}, \kappa_{nb}^{post}, \theta_{pre}, \theta_{post}\}$$

by matching model-implied optimality conditions to their empirical counterparts. The moment conditions are constructed from: (i) deposit- and loan-pricing optimality conditions; (ii) reduced-form estimates of the credit–deposit multiplier in the pre- and post-regulation regimes; and (iv) the nonbank credit pricing condition, estimated separately in each regime.

Let $\mathcal{T}_0$ and $\mathcal{T}_1$ denote the pre- and post-regulation subsamples, respectively, and let $\text{post}_t \equiv \mathbf{1}\{t \in \mathcal{T}_1\}$.

$$g_T(\Theta) \equiv \begin{bmatrix} \frac{1}{T}\sum_{t=1}^{T}\Big[(r_t^S - r_t^d) - \frac{1}{\alpha_d(1-s_t^d)} + \tau\,\frac{1-\chi_t\psi_t}{\Lambda_t} - \xi\,\frac{\kappa}{K_t}\Big] \\ \frac{1}{T}\sum_{t=1}^{T}\Big[(r_t^\ell - r_t^S) - \frac{1}{\alpha_\ell(1-s_t^L)} - \tau\,\frac{1}{\Lambda_t}\Big] \\ \frac{1}{T_0}\sum_{t\in\mathcal{T}_0}\Big[\widehat{m}_t^{\text{pre}} - \frac{1}{1-\theta_{\text{pre}}\lambda_t^{\text{pre}}(\tau,\xi,\kappa_{nb}^{pre})}\Big] \\ \frac{1}{T_1}\sum_{t\in\mathcal{T}_1}\Big[\widehat{m}_t^{\text{post}} - \frac{1}{1-\theta_{\text{post}}\lambda_t^{\text{post}}(\tau,\xi,\kappa_{nb}^{post})}\Big] \\ \frac{1}{T_0}\sum_{t\in\mathcal{T}_0}\Big[(r_t^{nb} - r_t^S) - \frac{1}{\alpha_\ell(1-s_t^{nb})} - \kappa_{nb}^{pre}\,L_{nb,t}\Big] \\ \frac{1}{T_1}\sum_{t\in\mathcal{T}_1}\Big[(r_t^{nb} - r_t^S) - \frac{1}{\alpha_\ell(1-s_t^{nb})} - \kappa_{nb}^{post}\,L_{nb,t}\Big] \end{bmatrix} = \mathbf{0}. \tag{63}$$

Appendix A.7 Implied Balance Sheet Slack Variables

Next we provide additional details on the evolution of the capital and liquidity slack variables used in the model. Capital slack is defined as the difference between available equity and required equity under the statutory capital requirement. Liquidity slack is defined as the difference between liquid assets and runnable liabilities scaled by regulatory liquidity parameters. Both slack variables are functions of balance sheet quantities and therefore vary over time with the evolution of deposits, loans, wholesale funding, and equity. Figure A.1 plots the implied quarterly series for capital slack and liquidity slack over the sample period. The figure illustrates a pronounced tightening of both constraints following the financial crisis and the implementation of post-crisis regulatory reforms. These movements play a central role in shaping pricing behavior and the propagation of deposit shocks in the model.

Figure A.1: Model Implied Structural Parameters

The figure plots the implied slacks (K_t, Λ_t). The vertical line marks the start of the post-reform regime. Lower values indicate tighter constraints.